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Plant Operation

SEWAGE WORKS PRIORITIES—A SYMPOSIUM *

HON. MAURY MAVERICK
FREDERICK G. NELSON
DON. E. BLOODGOOD
A. M. RAWN, *Chairman*

I. PRIORITIES AND THE WAR PRODUCTION BOARD

BY HON. MAURY MAVERICK

Director, Government Division, WPB, Washington, D. C.

Several months ago, after I had been informed that the War Production Board was in bad odor with sewage works engineers and operators I accepted an invitation to address the New Jersey group, one of your constituent organizations, in Trenton. I had in mind the idea of acquainting that group, and through them the rest of the Federation, with the duties and policies of War Production Board. I wished to determine what, if anything, was materially at fault in our management of your problems and what changes of advantage might be made. Before addressing the group, I discussed the matter with three of your colleagues: Messrs. Enslow, Raisch and Schroepfer. These three men told me a lot about the general problem and specific details of American sewerage practice, what it hoped to accomplish; what it was doing, and what was needed in the way of assistance to maintain sound working conditions. They told me something of what might be in the minds of my auditors and what were their perplexities.

Profiting by their advice, I prepared a speech which has had some considerable publicity in the national journals peculiar to your profession. I spoke of what was in my mind regarding priority assistance to sewerage projects, dwelt to some extent upon the problems of operation and maintenance, encouraged the New Jersey group and through them, all sewerage men to use the facilities of Government Division to the fullest extent and promised that prompt attention would be given to your applications and questions.

The opportunity of speaking at Trenton was greatly appreciated. It gave me an excellent insight into the sewerage problem of the country as a whole, into the local problems in and about New Jersey and into those things which were concerning the sewerage operators and did not appear to be answered or adequately provided for in our directives or procedures.

* Presented at Fourth Annual Meeting, F. S. W. A., Chicago, Illinois, October 21–23, 1943.

At that meeting, I made a promise to the three men who had acted as my advisers. It was that we of the War Production Board would establish a Branch in Government Division to handle all matters relating to sewerage and refuse disposal and that we would appoint whoever these three men recommended to be the Chief of the Branch. Upon their recommendation, we selected one of your colleagues, an officer in your Federation, an engineer and operator, Mr. A. M. Rawn and requested him to spend enough of his time in Washington to organize and at least initially direct the efforts of the Sewerage and Sanitation Branch. We are greatly indebted to him for the work which he has done. Within three months after his appointment early in April, he had completed a revision of the operators priority rating order P–141, that greatly simplified operation procedure; had effected changes in construction application procedure which made material savings in time and money and had completed within the Division a branch designed to handle all problems relating to refuse disposal, sewerage and allied activities. To Mr. Rawn and to Messrs. Enslow, Raisch and Schroepfer I extend the thanks of the War Production Board and my congratulations upon the character and efficiency of the work which they have completed.

From these representatives of yours we asked for constructive criticism—which—by the eternal, we got and took and applied.

I saw the logic of it because I had run a sewer system as Mayor—I mean a real sewer system, not a political sewer—for two years without knowing much about the business except that you had to have competent engineers to do the work. As head of the Government Division of the WPB, I knew that billions of dollars were invested in sanitary works of all kinds and character, with which the members of your Association are familiar. I had sense enough to know that this great job which you are doing was the basic essentiality of a healthy nation, and that we could no more do without this service than we could do without food and soldiers.

Since that time, I have found out and have begun to know equally well that constant vigilance and constructive maintenance and operation and timely repair and necessary extensions are essential to the continued and effective services of these facilities. And I know that it has been the members of your Association who helped the War Production Board, both with their advice and by their continued support, and you have done us an overwhelmingly great favor—and that is getting us to take A. M. Rawn as head of this. He has done so at a financial loss and to the eternal credit of your Association and to himself.

Now finally to get back to the recommendations of Enslow, Raisch and Schroepfer.

They indicated certain broad paths and general principles which such a branch should follow, and stated the general objectives which they believed should be attained. In short, from the standpoint of your profession, they set out standards which, modified by WPB regulations and restrictions, would result in adequate sewerage and sanitation facilities, maintained in good order throughout the land. These gentlemen criti-

cized the former priority rating order P–141; they advised me of its shortcomings, and wherein they felt it was not strictly applicable to the all-important field of sewerage practice. They stated what they considered were the weaknesses of our methods of handling sewerage problems, and in general left me with the impression that here indeed was a problem calling for a type of highly specialized knowledge—to be gained only from men whose lives and efforts had been devoted to its solution.

I am more than happy to tell you at this time that every one of their recommendations has been carried to fulfilment. As I have mentioned, P–141 has been revised to fit the conditions peculiar to your work. The former order PD–200 under which priority assistance for construction was granted, has been greatly simplified and is now far better adapted to sewerage, refuse disposal and other construction needs. Unnecessary proceedings have been eliminated in the foregoing orders as well as in the Controlled Materials Plan, procedure CMP 5A, all of which, as I have also already told you, was carried into effect with the advice of Mr. Rawn. Probably more to your interest than anything else, was the establishment of the Sewerage and Sanitation Branch, Government Division, which has now been in operation for over five months, and which has as its sole purpose effectuating an intelligent and cooperative liaison between you, who are engaged in the great task of keeping our urban centers clean, and the various Federal agencies which allocate the material assistance which will permit you to do so. That Branch is ably constituted of engineers familiar with your problems and is guided almost wholly by your Association and Mr. Rawn.

Let's review the WPB situation a little—particularly in its effect upon your work. WPB comprises many groups or divisions. Every agency in the country requiring material and labor for the conduct of its affairs is represented. The primary duty of WPB is to regulate supply and demand by determining the validity of each demand so that adequate supplies may reach those which are essential to minimum needs and maximum quantities of materials be available for civilian and military requirements to the end that the war may be successfully terminated with promptness and dispatch.

Since I spoke to your group in New Jersey, seven months of good fortune have greeted our efforts in combat. The United Nations have set the enemy back on his heels in several theatres of war. Our increasing tempo of production has been accompanied by additional success in transporting men, material, and supplies to the battle area—both in the Atlantic and the Pacific. During these seven months the enemy has had little from which to take comfort, while we, despite our losses in men, tremendous expenditures for materials and supplies, and no small civilian sacrifice, are entitled to a genuine feeling of optimism. We can now see some of the tangible results derived from the Herculean efforts which the nation has made.

Lest we become too optimistic, it is well to keep in mind the admonitions of our civilian and military leaders, that we temper our optimism with caution; that we maintain the attitude of a confident fighter in

the ring, who sees the fight going well for him but realizes that there are more rounds to come, and that the knock-out punch has not yet been delivered, nor the decision rendered in his favor. Therefore, while I join with you in this feeling of optimism regarding the progress of the war, I must at the same time, reiterate what has been stated so many times and what I stated in New Jersey: that is, we must continue to limit our construction, operation and maintenance activities to those which meet minimum civilian requirements. For how long—I don't know. The pressure from some quarters is relieved; that from others becomes greater, and the general over-all picture is still such as to demand what we think in terms of the war and that *it* be the greatest factor in consideration of our present needs and requirements.

Some critical materials are less critical. There is now a little more aluminum and copper for civilian needs. There is more cast iron in the form of pipe and sewerage accessories. Steel, in some of its forms, has eased off a little, but lumber is more critical than ever, and civilian manpower is at its lowest ebb. Thus while the war picture is brighter, and while we have just cause to derive great satisfaction from it, the brakes are still on—shortages, critical shortages, exist. We still are confronted with winning a hard, fierce and bloody struggle which will call for every ounce of our national stamina and resources, and we must judge all of our activities in the light of the battles to come, and not in the hope of easy victory.

Of importance to you is what probably all of you know, and that is that after the Sewage and Sanitation Section was established, the War Production Board assigned to it control over the production of all sewer cleaning equipment and sewage treatment machinery. This means that manufacturers of this machinery and equipment must get their metal under the controlled materials plan from the Government Division.

Before these product assignments were given to the Government Division, producers of this machinery were almost as unhappy over their treatment by the War Production Board as were some of the members of your association. We have been taking care of them since July 1. We have been able to allow a little increase in their production. We believe that they are happy and will be able to produce materials which will take care of all your legitimate requirements.

I wish to encourage postwar planning. Projects which may not show the necessary elements of essentiality at this time and for which priority assistance may not be granted by WPB may, and probably do, have all the essentials of good, sound immediate postwar construction, and I encourage you to test your projects—both as to essentiality now and importance for postwar planning—and to conceive and design those projects which, in less strenuous times, besides being essential to civilian needs, will merit and receive public support. In this connection I invite you to make full use of the facilities offered by the Sewerage and Sanitation Branch of the Government Division. Your problems will be promptly and conscientiously considered—each upon its own merits; but if you do not receive a response as quickly as seems desirable, remember

that ours is a large agency which receives thousands of applications daily, all of which must be read, recorded, routed, and acted upon in accordance with the law. This takes time, but we'll hurry it along as fast as is consistent with the importance of the query. And so this about tells this specific story of sewerage and sanitation in war.

But I know, Fellow Americans, it is needless for me to end my speech with any patriotic appeal. I have gotten to know you well, and I find you a well informed, intelligent, and patriotic group of men. Like me, you have sons and sons-in-law, and daughters and nephews and brothers and friends who now fight on our far-flung fields. These young men and women are on the Seven Seas, on every continent and island and land in the world, and they fly everywhere through the air, and sail, and walk, and fight on.

We are proud of these young Americans, and we will do all we can to keep this country clean—clean physically, morally, industrially and economically. We will do this in order to preserve the American system, and make it so we will have a decent country in which to live, and a place where free men and women, and our returning soldiers, sailors, coast guardsmen, and Marines may get jobs, and live as they will deserve to live for the brave and faithful service rendered this country in time of need.

I want you to know my personal attitude on the matter of building in sewage now, or later. This attitude, in fine, is exactly like your attitude; and that is, to do as much as possible within the war effort, and to do what is necessary to maintain the health and safety of this great nation and the communities which compose it.

And so my friends, I again thank you for inviting me to address you here. You have our confidence, we have done our best, and you have done your best. All together, I think we have done a good job. But now we raise our head above every little or specific thing, and dedicate ourselves to the whole cause of America. Continuing to do our duty, we will keep fighting until America is free.

II. MECHANICS OF PRIORITIES

By A. M. Rawn *

Special Consultant, Government Division, WPB

Mr. Maverick has told you something of the Sewerage and Sanitation Branch of the Government Division of WPB and has implied that I am your representative in that agency. The branch is a separate unit which deals specifically with your or rather, I should say, our problems. Government Division is similar to War Utilities which latter deals with transportation, gas, electricity, communications, etc., whereas govern-

* Also Chief Engineer and General Manager, Los Angeles County Sanitation Districts, and President, F. S. W. A.

ment is concerned with those functions of public service in government which are not strictly utilities.

We have a small branch and believe it is doing a good job. Three engineers administer its functions—Mr. Henry Evans, the acting chief; Mr. Mathew Sullivan, one of the principal analysts and Mr. Bart Marshall, all of whom have knowledge of sanitation, sewerage and refuse disposal. Mr. Evans was unable to be here today because of illness.

When the branch was created, our first desire was to establish certain criteria of essentiality—the sort of thing I call a "tickler"—and this job was promptly completed with the cooperation and understanding of Mr. Maverick. These criteria are used to put every priority request on a common basis so that judgment may be passed fairly. The set of questions thus developed enables us to judge each project with a common pattern of rules.

This, then, was how Form 2814.3 came into being. Form 2814.3 is the one that asks you a number of questions about your project and, from these questions, you yourself are able to make a fairly good determination as to whether or not the proposed job is an essential one. When this preliminary inquiry form (2814) is filed with the Sewerage and Sanitation Branch, we in turn may decide whether the project is essential. If so deemed, the project is approved and you are advised that you may proceed with the detailed design and to prepare the detailed WPB-617 (formerly PD-200) application with complete assurance that priority assistance will be forthcoming. As a result of the published criteria questionnaire 2814.3 about 80 per cent of all the applications which are forwarded to us are acted upon favorably in all departments of the War Production Board.

The revised Order P-141 is in part responsible for this record. You will recall that P-141 in its original form was a utilities order modified slightly in an attempt to make it applicable to sewage works.

The principles and problems were entirely different. The utility has its distribution system to carry something which it has to sell its customers, such as electricity, gas or water. Sewers offer nothing for sale—they serve in a fashion similar to the gutter in the street or a sidewalk.

I stated to Mr. Maverick and his advisers my firm opinion that no money was being spent in sewerage practice for unnecessary purposes. In other words, in nine cases out of ten the applications were worth considering very seriously. Perhaps the person filing the application was unfamiliar with wartime construction procedure but the work he proposed was usually necessary or there would be no demand for it. Sewers are not built for pleasure or just because a city happens to have money. They are usually not self-supporting and there is usually no sinking fund or other backlog to furnish funds for their construction.

In any event, the original Order P-141 was chopped to pieces and put back together again in such a way that I am convinced that at least 80 per cent of all the 6500 treatment plants in these United States can operate without recourse to quarterly inventories or much of anything else. In the present form, most of the old restrictions are eliminated,

except for the larger plants where precise inventories are a necessity and are kept anyway.

To facilitate application of the various orders and forms, I prepared a pamphlet called Bulletin 2, which has undergone careful scrutiny in WPB. The bulletin begins with a general statement about the essentiality of sewerage service and then goes into the use of the applications for construction projects (Forms 2814, 2814.3 and WPB–617) which I have already briefly discussed. The limited construction allowed under Order P–141, that is, $1,500 in the case of underground sewer or pipeline extensions and $500 for other additions or expansion of facilities above ground, is explained. Next, Bulletin 2 explains the use of Form WPB–541 (formerly PD–1A) for the purchase of new equipment where no new construction is involved. Considerable space is given in the bulletin to the use of Order P–141 which is our own order and is designed to enable us to obtain maintenance, repair and operation materials and supplies.

Briefly, P–141 assigns a preference rating of AA–1 to supplies for maintenance, repair and operation but warns against using the rating to obtain scarce materials possible of elimination without serious loss of efficiency. It assigns the lowest preference rating given to a rated project to construction of sewerage facilities to serve such project but qualifies this with the provision that WPB authority is prerequisite to commencement of construction of such facilities. That is to serve housing projects and plant corporations, etc.

P–141 prescribes the method of obtaining controlled materials, such as steel, copper and aluminum. Incidentally, it allows 100 pounds of aluminum per quarter for plants merely by placing on the order the special certification provided for the purpose.

It prescribes the certification for use in applying the AA–1 rating.

It establishes the year 1942 as the base year for operation, repairs and costs and divides it into four quarterly periods, where the expenses are over $1,000 a year, so the customary procedure may be followed.

All reference to classes of materials is eliminated in P–141 except where you are replacing materials in inventory. That did much to eliminate confusion in the minds of many operators who directed it to my attention. That is, if you spent $2,000 in 1942 for cement, you could spend $2,000 in 1943 for lumber, or anything else. You are not limited in 1943 or subsequent years to the class of materials that you used in 1942. While the class restriction is necessary and essential in some departments of the War Production Board, it is not in ours, because the order of magnitude of the problem was not so great.

P–141 provides an increase in expenditures in proportion to increase in dry weather flow from year to year. Chemicals and fuels are allocated materials and are not included in P–141 limitations. It also provides for setting quarterly, annual allotments of supplies upon specific authority of the board, and gives the operator the opportunity to extend the limitations of the order pursuant to a letter, telegram or telephone communication to the Sewerage and Sanitation Branch of Government Division, WPB. It thus establishes direct contact with the

The reason the Mining Equipment Division controls the manufacture of sewage equipment is due to the wording of the Limitation Order. It provides that a manufacturer of mining equipment must submit his schedule of all orders, irrespective of their End Use, and that all come under the regulations of the Limitation Order.

The supplying of motors and gearmotors of 1 HP and over is limited under General Conservation Order L-221. Before these units can be supplied, the customer must furnish us with a certification properly filled in and signed. In general the customer certifies he does not have on hand idle units, except operating spares, which would serve the purpose. The customer also gives the names and addresses of three firms dealing in used motors from whom he has endeavored to obtain the electric equipment.

All manufacturers now have been operating under the Controlled Materials Plan since April 1, 1943. It has proven to be a satisfactory means of getting steel, copper and aluminum to points where needed most. Up to now allotments have been granted to Industry on a quarterly basis. Very soon we are promised that allotments will be granted on a yearly basis. This will be of further help to Industry as it will eliminate the necessity of filing applications four times each year. It is the opinion of most manufacturers that the CMP, since its inauguration, has greatly facilitated their obtaining needed materials.

IV. PRIORITIES AND THE OPERATOR

By Don E. Bloodgood *

Associate Professor of Sanitary Engineering, Purdue University

I believe that you will agree that priorities have been considerably clarified since we were confronted with them a number of years ago. No doubt the efforts of Mr. Rawn have been instrumental in simplifying the procedure to the point where it is no longer a larger job to obtain the priority than it is to do the job after the materials have been received.

The Pamphlet No. 2 "Sewage and Refuse Disposal," written by Mr. Rawn and published by the WPB, and republished in the September 1943 Sewage Works Journal, is the clearest, most concise publication I have seen. Let me suggest with further emphasis that you use it as a ready reference if by chance you are still bothered by priorities.

At the start of allocation of materials I found many individuals who seemed to feel that they were to be denied all rights to maintain their equipment and services in a satisfactory manner. Possibly they were right at the time but I doubt it. Certainly, today we have assurance that our problems are being kept very much in mind and that, within reason, the sanitary facilities of our people will be maintained. In fact, I have heard rumors that there was or had been some concern expressed

* Formerly Superintendent, Indianapolis Sewage Treatment Works.

by "the powers that be" to the effect that maintenance and supply stocks were dropping below a standard which should be maintained. If this rumor is true it means that the purchasers are going to the extreme in savings and conservation, or they are afraid of priorities. It is doubtful that the fear of priorities should, now with its simplification, be the stumbling block to proper maintenance of services.

Even in view of the fact that obtaining priorities has been materially simplified I am a strong advocate of establishing extremely friendly relations with certain companies from whom purchases can usually be made, as they can be of great assistance in obtaining materials in a time of emergency. I do not mean to infer that they will evade regulations but rather to point out that their experience with priorities often is of great assistance, their knowledge and suggestions on possible substitutions is of great value, and in certain instances they may even know their competitor's stock so well that they can tell you where to secure the necessary material much more quickly than you can locate it yourself. If you have been a good customer they want your business after the war, so they are doing all that they can to help you now.

So now, with the knowledge that the WPB insist that sanitation services be maintained, that most plant managers are conserving even more than was hoped for, and that industry and business is lending every effort possible, I am sure that we are going to make the grade.

V. PRIORITIES FORUM*

Mr. John W. Alden (Wilmington, Delaware): Mr. Maverick, what is the possibility of obtaining sewage plant equipment in the case of a plant that is already overloaded and is being required to take on additional load to serve a new housing project?

Mr. Maverick: I should say that where there are additional housing facilities to serve and the new equipment is needed to protect the health and welfare of the community, that it would be up to us to help you find a way to get it.

Chairman Rawn: Yes. Application for priority assistance could be made on Form WPB–541, or, if new construction is required as well as new equipment, on Form WPB–617.

Mr. Carl B. Carpenter (Hammond, Ind.): What would be the general attitude of WPB with reference to the construction of facilities necessary to abate stream pollution which affected public water supplies; where correction of the problem involved the purchase of considerable critical material such as steel and special piping?

Mr. Maverick: Such as where an industry is damaging a river used for water supply? Well, I would say that the primary consideration is whether or not the public health and welfare is involved, and how much. If it is merely a matter of pollution which does not affect a wide

* Open discussion at the Fourth Annual Meeting, Second Wartime Conference, F. S. W. A., Chicago, October 21–23, 1943.

area or a large number of people, WPB could not help much unless the material situation eased up. However, if it was pollution to the extent that health and welfare were menaced seriously, the War Production Board would do something about it. I have in mind several seacoast cities at which sewage is discharged to the ocean, resulting in very bad odor nuisances and hazards to swimmers. This is an extremely undesirable situation, but the public health is not seriously affected, and therefore, we can do nothing about it. I would say that each case would be handled on its own merits.

Another thing, speaking as a former mayor, I recall several industries that discharged pollution to the river and put the city to considerable expense to clean it up. I do not have much sympathy for some of those industries and feel that they should solve these problems for themselves.

Mr. Leo Holtcamp (Webster City, Iowa): If a plant is equipped with a piece of machinery that could be replaced by a more modern unit and bring about a saving in manpower, time and operating cost, would it be possible to obtain the better equipment and discard the old?

Mr. Maverick: I do not think so because the shortage of machinery is too great at this time. The rule is that you can get as much material as is available for sewerage and sanitation service in view of war conditions, and which is not needed for destroying our enemies.

May I add this comment about our Sewerage and Sanitation Branch. I do not want to compliment Mr. Rawn to the extent that I harm him but I want to make it plain that he has done a fine job in establishing our policies and training our engineers. The effectiveness of the present branch is proven by the enormous reduction in paper work from the early days of the WPB. We know that we are doing a better job now and most of our past mistakes have been corrected.

May I suggest that you have respect for and use your regional WPB offices when necessary. We are decentralizing in favor of these offices all the time and their capacity to serve you is constantly increasing.

Mr. T. C. Schaetzle (Akron, Ohio): Mr. Rawn, in Akron we have four synthetic rubber plants and three reclaiming plants. They necessarily overloaded our treatment devices, but what I am primarily interested in is, would they be reasonably certain of obtaining priorities for individual treatment plants not because of the effect it would have on our treatment plant but because of the saving in rubber? I might add in some instances the losses are, in my opinion, rather excessive. They run in the reclaimed plants anywhere from half of one per cent up to 12 per cent of the total production. Of course, that is based upon just two days sampling at each plant. Right now we are making a resurvey and shortly we will be confronted with the necessity of approaching them to do something to improve their treatment processes. My question is, would they receive favorable consideration from WPB under these circumstances?

Chairman Rawn: That would be a problem for the Industrial Branch to answer. It isn't specifically a government problem when it comes

to the reclamation or saving of reclaimed or other types of rubber in an industrial plant. I can say, however, that if your plant were being degraded to the extent that there was nothing you could do but to bypass appreciable quantities of untreated wastes, then you would receive priority assistance through the Government Division. As to the industry that comes under an entirely different branch of the War Production Board, and I couldn't answer. I assume on the basis of essentiality or on the saving in rubber, they would receive assistance. I just assume that; I don't know.

Mr. Schaetzle: It is true, we are overloaded in solids about three and a half times and there are war industries below that use the river water. We haven't had any specific complaints but the river has changed materially. I have tried to look for an argument that would get them to do the work.

Chairman Rawn: You have cited the argument. If they are wasting rubber, I would think WPB would be glad to extend priorities if a saving of rubber or critical materials would be saved thereby.

Mr. L. H. Enslow (New York): Mr. Chairman, I would call this a situation which probably exists at many places over the country, if not now, maybe later, and I am just wondering if the thing to do in a case of that kind wouldn't be to file a parallel application with cross reference so that the Government Division knows this has been filed from the industrial angle, and vice versa. It would seem that if we go at it from two different points it should land at the right pocket eventually.

Chairman Rawn: If the reference is perfectly clear that the other application has been filed, that would be all right, but let us get back to that over-worked statement—criteria of essentiality. The criteria of essentiality are entirely different from the two different approaches. One is a matter of public health and safety and the other is a matter of business and industry—saving rubber. From the health and safety angle to the citizens of the community, if it is a government problem, that is our problem. If it is to be approached from that angle, that is a Sewerage Branch problem in the Government Division. If, however, it is a matter concerning rubber, that is not our problem at all. That is industry's problem.

Mr. Enslow: I have one more thing to say. Mr. Alden asked a question a little while ago which was really covered in your last remarks about WPB having to know as far in advance as possible about how much material is going to be needed. That means certainly from quarter to quarter, which has been difficult to estimate. I wonder why they haven't made it semi-annually because you can catch up with yourself in that case. All of this problem is an essential problem as I understand it because of governmental housing. Mr. Alden hopes to enlarge his plant and needs it pretty badly, but before he can get that through, the Governmental Division and WPB must know in advance how much material all over the country is going to be needed or else you won't be able to get it in before about 1945. Eventually you get it. If you are

going to get it in 1944, really now is the time to estimate your needs, and that is a very important consideration at this time.

Mr. Lloyd Nelson (Washington, D. C.) *: It isn't actually on a quarter to quarter basis. The estimates are made up on January first. The estimate will go in for the second quarter of 1944 plus four quarters, so actually they will need to know roughly all the materials you will require for major construction up until July 1, 1945, by the first of this year. You have an opportunity to modify it each quarter but the estimates of what you will need for at least the next two years ought to get in before the first of the year.

Chairman Rawn: I think it is very important that you recognize the essentiality of getting in your statements. As I say, I have a list of those places here and it would take almost fifteen minutes to read it. It is very difficult to keep information up to date on a national basis.

Mr. Nelson: In connection with the question that was raised about manpower verses equipment, I thought it might be well to say a bit more. The manpower involved in making automatic equipment and the demand for that type of equipment for war purposes is so great that it is not possible to get it and it is necessary either to secure new or keep on operating manually operated equipment rather than automatic equipment that would save manpower. You must consider the total amount of manpower and the available materials for making the new equipment as well as the manpower in use in your plant to operate the equipment afterward. Is that clear?

Mr. J. M. Mercer (Chicago): Here is a routine operating question. It comes from our own situation where we applied for and were given permission to purchase rather a large quantity of critical material—a quantity large enough that it would cause us to exceed the inventory quotas established by order P–141. In the application, we asked for authority to make the purchase without including that amount in our quota for the year. Now the commission to purchase came through all right but we did not get the authority to eliminate that item from our accounting. I am wondering whether I am going to have to go to jail if we exceed our limitations.

Chairman Rawn: That purchase is not included in your inventory quoto if you got direct authority from the War Production Board to buy. If you get authority from the War Production Board you are not using P–141 except in some of the implications. You are not specifically bound by it.

* Consulting Engineer, War Utilities Branch, WPB.

PROBLEMS OF SEWAGE TREATMENT PLANT OPERATION UNDER WARTIME CONDITIONS*

By W. W. Mathews

Superintendent, Gary Sanitary District, Gary, Indiana

One year ago at the Wartime Conference in Cleveland, this Federation heard Mr. A. M. Rawn in his paper, "The Influence of This War Upon Sewerage Problems," forecast the increasing difficulty that would occur in obtaining materials and in maintaining personnel. We have seen this occur with scarcities of practically all materials, particularly those in the critical list and the depletion of personnel through men entering the armed services, or being attracted to other employment on account of higher wages. It might be well at this time to review briefly the conditions that obtained at that time on the various war and home fronts and compare them with present conditions.

On the war front one year ago the Allies were not in a particularly advantageous position. We had won few victories. Behind us was the history of Bataan and Corregidor, and General MacArthur was planning a further offensive in the Far Pacific. What might happen on the Russian front was still more or less problematical, and in Africa there had been numerous advances and retreats with Rommel finally being forced back from El Alamein. On the home front, construction was being carried on at a feverish pace to get the various war plants into production as soon as possible. Production was being stepped up, but not at a rate satisfactory to the General Staff. Demands for critical materials for plant construction, munitions and civilian needs were making it necessary to use substitutes for critical materials wherever possible. Training the various branches of the armed services was being carried on around the clock and the rate of induction into the services was constantly being stepped up.

Today the picture is considerably different. Victory after victory has been won on every Allied front. At home construction of war plants has been practically completed, although combat experience has shown the need for more equipment of certain types not originally anticipated. As a result some war plants are being converted to the production of war machines entirely different than those for which they were designed. A change of this kind requires critical materials. Production has increased, resulting in a greater demand for critical materials for munitions, making it still more necessary to stretch the available supply by making use of those less critical.

The Wartime Conference of the American Water Works Association held in Cleveland in June of this year was advised by the War Produc-

* Presented at Federation's Fourth Annual Meeting and Second Wartime Sanitation Conference, Chicago, Illinois, October 21–23, 1943.

tion Board that the total demands for steel in the third quarter of 1943 would exceed the supply by one-third. Since that time, the WPB has announced a cut of fifty per cent in public and industrial construction for 1944 and further, that each case be decided on its own merits, the general rule of essentiality being,—Is it immediately needed for the war effort, or can it wait until peacetime? Even oil company expansion projects already under way have been halted. Manpower shortage with continuing shortages of lumber and steel are given as reasons for this curtailment. The War Man Power Commission estimates that several hundred thousand men can be shifted from the building and building materials trades to war industry if construction is cut approximately fifty per cent. Generally speaking, we may say that while at this time conditions on all war fronts are greatly improved over those of one year ago, there is still an emergency as regards critical materials for all war production and civilian needs, and that this will probably continue for some time. Hence, we should not expect any relaxing in priorities for the purchase of critical materials.

With the instituting of priorities to conserve critical materials, probably for the first time in their experience, operators found, for a short period, that it was difficult and in some instances practically impossible to obtain certain replacement materials. Construction materials for treatment plants, for army camps and certain war plant areas are not included in this classification, since they, of necessity, had to be included as part of the war program. Treatment plants confronted almost overnight with overloading by increases in population working in adjacent areas, or from industrial wastes, were in an unfortunate situation and needed immediate attention. Government aid later took care of many of those cases.

Personnel losses were, in general, of two kinds. Where some employees were taken by the armed services, others left to work on construction or in war plants. The combination of the two left in some plants a much depleted and inexperienced personnel. With budgets of municipal plants limited, either by finances or by law, it was not possible in most cases to train replacements long enough to have an experienced operator ready to step into a job when it became vacant. Even a replacement formula with sufficient funds on hand for its proper administration is not workable when men are not available for vacancies.

One result of the man power shortage has been the employment of men above the age normally employed. In our case, the average age of laborers has changed from the fall of 1940, when the plant went into operation, from about thirty years to approximately sixty-five years at present. At Gary where four men make up the outside operating force, five replacements have been used since the war program started, making the turnover 125 per cent. Two graduate chemists constitute the laboratory force, and since February, 1942, eight additional chemists have been employed, with a turnover of 400 per cent. We were fortunate in being able to hire two women chemists about one month ago, which we hope has solved the laboratory problem for the duration.

In addition to the problems of supplies and personnel is the reduction of truck mileage under the Office of Defense Transportation. Most sewage treatment plants are located some distance from the center of the city, and in some instances well beyond the city limits. There may be in addition, sewage pumping stations that require limited supervision. At Gary, one small trickling filter plant about ten miles from the main treatment plant, and three small sewage pumping stations in the easterly and southerly parts of the city are operated by the Sanitary District, making it necessary to do considerable driving to insure continuous service. To keep truck mileage down to a minimum all trips are scheduled in advance. It would appear that just at those times when mileage limits are being approached, breakdowns occur, making extra trips necessary. The use of bicycles was considered in an attempt to reduce truck mileage. Analysis showed that the pickup truck was used on inspection and repair work, carrying several one gallon sample bottles for sewage and industrial waste, or tools and repair parts if out on maintenance. It was decided that it was not practicable to use bicycles.

One problem that has been minimized by wartime conditions is that of sludge disposal. Operators report increased demands for sludge from Victory gardeners to such an extent that at some plants the stock-pile has disappeared with a waiting list of orders on file. Where sludge has been sold there has been an increase in revenue. At Gary the opposite has occurred. In 1942, slightly over 5,000 cubic yards of sludge were removed, but total disposed of so far this year would indicate that this years removal would not equal that of last. Use of sludge has been popular at Gary since May, 1941, when it was first made available, with over 7,000 registrations in the sludge book to date. It would appear that gasoline rationing is responsible for the decrease this year. No charge is made for sludge and customers are allowed to remove it from the beds.

All operators are familiar with the several changes that have been made in priority ratings since they were first established. These changes have been made towards a simplification of procedure for obtaining materials necessary for plant maintenance. You heard this morning how the Operations Division, P–141 of the War Production Board is being administered to care for your needs, so that subject will not be taken up in this paper. It may be of interest, however, to those who are faced, or likely to be faced with an emergency requiring the purchase of essential equipment, as to how a case at Gary was handled by the P–141 Division of the War Production Board. A short time back, inspection showed that the impellers on the three 20 M.G.D. gas engine driven sewage pumps were badly worn from sand. Since these are the largest pumps in the plant and which are operated most of the time, it is necessary that they be maintained at normal capacity, or flooding of numerous basements in the city will occur during storms. It was first thought that replacement might wait for the duration, but a later inspection showed the wear increasing rapidly with marked de-

crease in both capacity and efficiency. The Board of Sanitary Commissioners decided to investigate and see if it were possible to make the replacements at once.

The pump manufacturer was first consulted and he advised that it would be necessary, on account of the existing conditions, i.e., large amount of grit handled, to replace the bronze impellers with cast steel construction, reinforced on the edges with stainless steel. Also, that in his experience, there were very few cities that had found it necessary to adopt that procedure. Since the cost of the new impellers with accessories would amount to approximately $4,500.00, it was obvious that our quota limit would be exceeded and it would be necessary to obtain the authority of the War Production Board to make the purchase.

An appointment was made with the regional office of the War Production Board in Chicago and the nature of the emergency explained. Our particular problem was handled by Mr. W. K. Evans of the above office. In spite of a desk piled high with unanswered correspondence, we were given an unhurried and sympathetic hearing. If anyone questions that particular type of interview, I believe that any operator, confronted with a breakdown in operation after working long hours to maintain service, will agree that it is a pleasure to find sympathy outside of the dictionary. We were advised to wire Operations Division in Washington in detail,—the "detail" being emphasized, explaining the nature of the emergency and follow up the telegram with a letter. Four days after the letter was written, authorization of purchase was received. In these times no one could ask for better service than the above.

May I suggest that if you are located within convenient travel distance of a regional office, that you take your problem direct to headquarters where advice as to procedure may be obtained. It is much easier and simpler to explain your problem across a desk than by correspondence. Literally hundreds of letters are handled each day by the priorities section where men are trying to assist you as much as possible, and one criticism of the applications has been that many of them do not furnish enough detail to permit the request being granted immediately.

After authorization for purchase has been received, it will soon be learned that the bottleneck in procuring needed replacements is not in the Office of the War Production Board, but is in obtaining the material from the manufacturer. This statement is made without intending in any way to criticize the producer. In these times almost every plant is engaged in war production work of some kind and is being pressed to speed up deliveries. Even if the plant in question has an inventory that would permit filling your order with an AA-1 priority rating, the production line cannot be interrupted to handle your particular need. It will have to be scheduled and take its turn unless through some happy circumstance it can be worked in along with production routine. That would be the exception, however, rather than the rule. Probably no one would expect to find a spare part in stock with inventories down to the vanishing point in most factories and shops.

In our own case, it took only four days to get the authorization to purchase, but delivery f.o.b. the works was promised in twelve weeks. Whether that schedule can be adhered to is yet to be determined, but it is a reasonable production time, particularly under present conditions. At this time the writer wishes to express the appreciation of the Board of Sanitary Commissioners of the Gary Sanitary District to the War Production Board, Operations Division, P-141, for the efficient manner in which our authorization was processed, and which I am sure will be concurred in by other operators who have had emergencies occur which necessitated similar action.

Closely allied to the purchase of critical materials is the question of inventory. Where a utility is serving the public collectively, as is the case with a sewage treatment plant, the inventory problem is not critical. If the utility is serving the public individually, the case is entirely different. With gas, water and electric plants, a considerable inventory of various kinds of supplies representing a large investment has to be maintained. The sewage treatment plant has no such problem and unless there is some part of the plant which requires continual maintenance, no large stock of spare parts should be required. Where a plant is depending upon gas engines as prime movers, all that is required is a few extra valves, valve springs, valve inserts, magneto, a spare block or two, depending upon the number of engines in service, with the necessary packing, gaskets and gasket material to make ordinary repairs. That list naturally does not cover all needs of all plants, but with a few additions it will in general cover the requirements of most plants. Pump replacement ordinarily is required only at long intervals and need for this can usually be foreseen. It will be noted from the above that a large investment in inventory is not required for the average sewage treatment plant even in these times. Pre-war conditions were such that a long distance call or a telegram would bring in replacements almost overnight. It should not be inferred from the parts list given that the writer is advocating inadequate inventories, but is rather stressing the point that excessive inventories are not justified at a sewage treatment plant. Carry enough spare parts that experience has shown are necessary for routine replacements. Information furnished by other operators indicate that inventories are usually meagre.

The War Production Board is quite liberal in the wording of the priority regulations as regards inventory of spare parts for maintenance of service and also to care for imminent breakdowns. Since inventories as a rule are low at sewage treatment plants, it does not take much of a breakdown to exceed the quota limit and necessitate a request for authorization to purchase, when the amount in question may be only slightly above the allowable quota. If this section of the regulations could be made a little more elastic, it would benefit both the operator and the War Production Board. From the operators standpoint, it would cut down the time required to obtain the material desired and it would also appreciably reduce the correspondence in the office of the War Production Board.

In spite of the difficulties encountered with changing personnel, operators' records indicate that efficiency in the treatment process is being maintained except in special cases of overloading noted heretofore. Operating results at Gary for 1942 showed increases in pumpage and total pounds of solids received and removed with a decrease in pounds of 5-day B.O.D. received and removed. There were 7,929,967 pounds of 5-day B.O.D. and 14,011,858 pounds of suspended solids removed with annual efficiencies of 94.72 and 97.22 per cent respectively. Operating costs were $8.79 per million gallons and $8.39 per 1,000 pounds of B.O.D. removed. Gas production averaged 157,790 cubic feet per day, equivalent to 1.50 cubic feet per capita per day based on 105,000 connected population. Total value of sludge gas used, based on a contract with the Northern Indiana Public Service Company was $22,535.80.

Another problem that is apparent to all persons engaged in public sanitation, and which has not been particularly emphasized, is that of time. The days do not seem to have the number of hours they did in pre-war times. Probably every person here is carrying on some war-time activity outside his or her regular vocation, and it is remarkable that everyone has been able to take on so much additional work. Among the many organizations that have in particular suffered numerous losses in personnel and at the same time had to assume extra work are the various State Boards of Health throughout the country. It has been the privilege of the writer to be associated with the Indiana State Board of Health through work on the State Emergency Committee for the Maintenance of Water and Sewage Treatment Plants in cases of bombing, sabotage or serious breakdowns. A recital of the work being done by one State Board can well serve as a record of one or all of them. War plants with their problems of water supply, sewage treatment and stream pollution have added heavy burdens to staffs already overworked, making it difficult to maintain the high standards of sanitation which have been developed through the past years. But with all extra work entailed by this World War II, the public may rest assured that all persons and organizations engaged in environmental sanitation will not relax their efforts to give the utmost in protection for healthful living.

Discussion

By Roy S. Lanphear

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Wartime operating problems of sewage treatment works or plants are generally due to one or more of the following difficulties:

1. Lack of availability of trained personnel.
2. Break down of mechanical units in a very unusual manner or to a serious extent.
3. Change of character of sewage due to the discharge of industrial waste liquors in larger quantities or to the discharge of an en-

tirely new waste liquor, either of which places a load upon the Works which is difficult to carry.

Sewage treatment and disposal is not interesting to the average member of the city government. Successful works operation bears no direct gain to the tax-payer and for that reason, would not cause the member of the city government to take a special interest in sewage treatment. For these reasons, I believe that at all times, the sewage treatment works operation should be placed upon a financial and man-power basis which represent true economy and at the same time, permits efficient operation throughout the entire year. In this way, the wartime man-power problem becomes serious only where extra labor which is used to considerable extent during the summer season becomes unavailable. We like to keep our lawns, gardens and buildings in excellent condition and appearance, but where removal of large quantities of dried sludge from beds are necessary for works operation, the latter presents a real man-power problem. The solution of this problem lies in providing suitable works equipment, together with sufficient regular man-power for its operation. This labor can be effectively used during the winter months in maintenance work.

You will note that I have excluded from my consideration, the technically trained employee and the employee who might be considered an absolutely essential worker because of the nature of his work and the difficulty of training a man to replace him. Deferments and exemptions are available to a certain extent in such cases. Training of men within our organization as replacements for men whom we expect to lose is a duty which must be performed. The logical solution of the problem of replacement of laboratory personnel lies in the employment of women chemists or women who can be trained to carry on much of the work. In this, I have been very fortunate in my selection of my assistants.

Every sewage treatment works should have a protected store-room, or rooms, in which reserve tools and spare parts of mechanical equipment are kept in orderly manner. In many instances, such as pumping equipment, stand-by units and spare motors are provided. Experience furnishes a good basis for judgment in providing for usual replacements. The unusual and serious break-down is the one which can not be foreseen and it is a matter to be promptly considered when war is declared. Wars do not occur as frequently as do changes or improvement of facilities for handling or treating sewage and sludge. Therefore, all of the factors which enter into such a possibility must be carefully considered at the earliest possible moment.

I have purposely made the change of character of sewage and a possible resultant deterioration of works operation my third and last point of discussion. Worcester sewage has been known far and wide as one which contains acid iron wastes from the wire industries of the city. In previous papers, I have shown the widely different results of trickling filter treatment of Imhoff tank effluent obtained during normal

pre-depression years as compared with the depression years of 1931 to 1937. Emphasis has been placed upon the successful operation of these filters when treating Imhoff tank effluent from sewage containing heavy doses of acid iron.

War-time industrial conditions in Worcester have now caused the sewage to become so acid that filter treatment of the settled sewage has been greatly affected. The nitrate nitrogen and dissolved oxygen content of the filter effluent have been reduced to fractional parts per million; its stability has decreased.

Special investigations have been made throughout the 24 hours on a number of occasions with the following results. The extremely acid sewage is caused by the spent acid wastes discharged by four industrial concerns. The average iron content of the sewage received at the works, expressed in parts per million, does not exceed maximum quantities received heretofore. However, it is true that the actual quantity of iron received during 1943 is greater than that received during the same period of time in 1942. No pooling of the filters has occurred. It is believed that the present operating difficulty is confined to the acidity of the sewage. (5.5 to 6.0—day hours and 5.0 to 5.5, night hours). However, the iron content of the sewage is closely checked in order that any marked change will be promptly observed.

Conferences have been held with the officials of the four concerns and their co-operation sought in neutralizing their waste liquors to a pH of 6.6 to 6.8. This matter is still under discussion, but it is hoped that successful solution of the problem will be forth-coming. Laboratory tests are keeping the Superintendent of the Bureau of Sewers posted on the existing conditions and preparation of a report by the Supervising Chemist covering lime treatment of the sewage is underway.

WARTIME PROBLEMS OF SEWER MAINTENANCE*

By John H. Brooks, Jr.

Superintendent, Bureau of Sewers, Worcester, Mass.

The condition of war has made its impact upon the economic and civic life of our entire country. Its effect upon every community, great or small, has been in a direct ratio to the activities in the military and defense operations.

In the months leading up to the declaration of War in December 1941 many communities had been conscious of wartime conditions. Industrial plants were beginning to rapidly expand and their production operations were being keyed up to an increased tempo. The increase in the employed personnel, often resulting in a large influx of new inhabitants to a community, brought with it the requirements for more housing and the attendant necessity for public services—water, electricity, gas, sewerage, etc.

The lure of high wages to satisfy the demand for additional war workers early made its inroad on the established personnel of municipal employees. With the declaration of war other factors came into the picture to further disturb the normal operations in the providing of public service of a community. The expansion of the armed forces with its drain upon available man power, and the limitations imposed upon non defense activities all of these increased the problems which were constantly before a public official concerned with the maintenance of sewers.

The responsibility for the operation of a public sewer system is a "round the clock" problem. No one can question the necessity for the speedy and adequate removal and disposition of the domestic and industrial wastes of a community. Any conditions which interfere with it soon produces a serious menace to its welfare and public health.

Wartime operation of a public sewer system do not materially alter or change from the standard practices in normal times. The day by day routine of repair to the existing sewer lines and appurtenances, the flushing and cleaning of sewers and catch basins, the operation and upkeep of pumping equipment, the constant attention to the complaints of citizens are ever before the maintenance personnel.

The extensive increase in industrial activities with its attendant growth in population has quite naturally produced an increase in the volume of sewage flow. The character of the sewage has in many instances changed because of this increase. The urge for volume in production, the 24 hour operation of these plants, the lack of adequate attention to the matter of plant waste all tend to materially change the normal characteristic of the sewage.

* Presented at Federation's Fourth Annual Meeting and Second Wartime Sanitation Conference, Chicago, Illinois, October 21–23, 1943.

In many localities it has been necessary to make extensive additions to the sewer system to care for new housing developments, additional industrial plants and military establishments. Undoubtedly many facilities at the Sewage Treatment Works have had to be increased. All these additions have produced increased volume of sewage flow. New sewers, however, like a new house, do not immediately present extensive maintenance problems.

The normal, as well as wartime routine of sewer maintenance involve factors quite familiar to all sewer officials. Adequate personnel, equipment and material are of prime importance.

Every organization responsible for the upkeep, repair and operation of a sewer system should have complete detailed information pertaining to it. This data should show the location, sizes and characteristics of all the sewer lines—both sanitary and surface, information covering private drains and sewers should also be available. The locations of manholes, pumping stations, force mains, siphons and surface water outlets are also important. All such plans and data should be kept up to date. Too often new additions and changes are not incorporated in the existing data and all too soon are forgotten. Duplicates of all this essential information should be maintained and kept available for the use of those concerned with the maintenance problems.

Fortunate indeed is the sewer department which has been able to maintain a permanent and adequate force familiar with its sewer system and experienced in the handling of the many and diverse emergencies which constantly arise. While much of this work involves tasks where unskilled labor can be used, a nucleus of key men, skilled and trained in maintenance problems is highly important.

Tools, equipment, and accessories are fully as important as the human personnel. These should be segregated and available at all times. Hand tools, pumps, air compressors and air tools are of prime importance. Constant advances have been made in the development and use of equipment peculiar to sewer maintenance. All of which have merit and can be advantageously used, in many cases relieving and supplementing the shortage of man power.

So much for plans and organization which, in my opinion, are quite the same in wartime as in normal times. What then has war conditions imposed upon the sewer practices?

Early in the transposition from peacetime to wartime, civilian defense with its many and diverse ramifications had to be considered and planned for. A study of available facilities—material, personnel and equipment was necessary in order to provide quick and adequate services which might be required in case of a major emergency. Definite plans had to be made for utilizing the regular maintenance crews supplemented by such auxiliary personnel as could be obtained. Consideration had to be given to being prepared for the disruption of the sewer system in many places simultaneously rather than scattered as in normal times.

The importance of plans and records became decidedly more impor-

tant. It was considered equally essential to provide for their duplication and safe guarding in separate locations thus preventing complete loss in case of the destruction of one set. Consideration was given to safeguarding from sabotage the sewer system, particularly the pumping stations and sewage treatment works. This required additional personnel and imposed increased expense.

The shortage of man power has been a serious factor to contend with in the operations of sewer maintenance and of sewage treatment works. In Worcester, because of age limitations relatively few losses in personnel has been experienced. We construct all of our sewers, maintaining a sizable permanent construction force for that purpose. This situation thus furnishes an available pool of labor who are quite familiar with the sewer layout and naturally are valuable for any necessary augmenting of the maintenance crews. Under war conditions such a situation is of great value and certainly a comfort to one responsible for the handling of any emergency.

Governmental control of equipment and materials has made the problem of procuring many items difficult and in many cases impossible. The classification of sewerage and its allied operations as an essential war activity has, however, provided for most of the normal requirements.

These wartime conditions have retarded the usual normal construction of sewers. In many cases, local health conditions have made necessary some additions; but, in the main major construction projects have had to be deferred.

Mention has been made of changes in the character of the sewage. In any community where industrial operations have been accelerated there may have arisen conditions which have had unwholesome effects upon the method and results of sewage treatment. This situation has developed in Worcester where extensive wire manufacturing activities are being carried on. A marked change in the acidity of the raw sewage has reduced the quality and stability of the final effluent at the Sewage Treatment Plant. The solution and remedy for this situation is being studied. It is definitely a war time problem.

Many other instances of wartime maintenance problems could be enumerated. Their origin and solution, however, can be traced principally to a shortage of man power. It isn't felt that public health has suffered from any lack of attention on the part of those charged with the maintenance and operation of this most vital and valuable public service. It is possible that many administrators have had their difficulties and worries but measured in degree of sacrifices undergone by the boys in the combat areas, these problems can be considered relatively simple.

WARTIME OPERATING PROBLEMS—BY THE DOZEN *

By Morris M. Cohn

Editor, Sewage Works Engineering, Sanitary Engineer, City of Schenectady, N. Y.

Eighteen months ago, the Japs sneaked in on Pearl Harbor and we found ourselves at war, despite the assurances of isolationists that war could never touch American soil. Since then, we have uprooted most of our peacetime habits and have learned to live a life of scarcities and uncertainties. We have many more months of such conditions ahead. They will be even more trying of our mettle.

Sewage treatment, being a process directly associated with community life, very quickly reflected the shift of American conditions from peace to war. This is not surprising since every change in home habits and in industrial and commercial activity reflects itself in the turbid depths of the sanitary sewer system. The trivial, as well as the cataclysmic events of community and country, leave their impress on the art of sewage treatment. The presence of the mash of prohibition days in sewage was no more obvious than the hulls that come down the sewer when Aunt Hetty starts putting up her preserves. For example, the scarcity of sugar has made people stir their coffee more vigorously and in the City of New York alone, it is estimated that 2,000,000 lbs. of cup-bottom sugar are no longer going down the drain. Most assuredly, we are beginning to feel the effect of war, in humorous as well as in serious ways.

The modern art of sewage treatment in the United States found its beginnings since the last war despite the fact that during World War I many sewage treatment plants were in operation here. Certainly, the vast majority of operators of treatment plants were not following this trying profession in 1917, judging from the fact that the Quarter Century Club of the Federation of Sewage Works Associations contains but a handful of men, and an old-timer like your Chairman failed by a few years to pass the qualifications for membership. It is evident, therefore, that most of us are experiencing for the first time the effects of war upon sewage treatment. It is well, then, that we stage a Round Table such as this for the purpose of analyzing what has happened and how we have met these happenings, and to plan for anything which might occur in the future.

I could enumerate every one of the effects which have been visited upon sewage treatment plants, because I have personally had many of them, have seen many more and have sufficient imagination to encompass the others. This would not be a Round Table if I were to devote the major portion of the morning to such a detailed enumeration of

* Paper presented at Spring Meeting of New York State Sewage Works Association, Rochester, N. Y., June 4–5, 1943.

war conditions and their effect on sewage treatment. It is the purpose of this meeting to have you place on record the experiences of operators in this State which has done and is doing every phase of war work and has felt every one of the effects of war on normal life.

Every one of your problems, no matter how local or how individualistic they may be, fit somewhere into the following twelve points of wartime operation conditions:

1. Increase or decrease in sewage flow due to shift of population to centers of war work and from points of non-production.

2. Increase of sewage flow due to concentration of men-in-training tributary to public sewer systems.

3. Change in rate of flow throughout the day or throughout the week, due to changed life habits of community dwellers, and the round-the-clock operation of industries that formerly made a strong point of the 40-hour-week.

4. Change in composition of sewage due to the production of industrial wastes, in unusual quantity or quality.

5. Effect of war on the 3 M's of Operation—Men, Materials and Mechanisms—the men to operate the works; the materials and supplies with which to perform operations and maintenance; and the machines with which or by which to perform our functions.

6. The tradition-blasting employment of women in actual sewage works operation tasks, as women on the production line have changed manufacturing to "femufacturing."

7. Increased cost of operation due to commodity costs and demands of labor for increased wage rates.

8. The effect of restrictive orders and priorities upon plant enlargement, revision, reconstruction or construction.

9. The swing of public opinion and national demands towards the utilization of sewage sludge as a fertilizing material; the use of gas for power production; the conservation of fish food by pollution prevention.

10. Protection against sabotage and bombing damage by blackout, protective lighting and fencing, training, camouflaging, etc.

11. The improvement of supply and manpower relationships between communities situated "in the same boat" of war emergency conditions.

12. The need for "looking ahead" to the post-war period when scarce materials will become abundant, when labor shortages will become labor surplus and when the unfinished problems of sewage treatment stand a real chance of becoming completed in the first decade after Victory.

Somewhere in the "12 Points" you will find place for every one of the emergency conditions which have in the past eighteen months convinced you that "war is hell." By a frank discussion of your problems you can help others to solve theirs; by a frank admission of your need for help, you can get advice from others who may have solved similar problems in their own communities.

Sewage Research

EFFECT OF ADDITION OF NITROGEN ON DIGESTION OF PAPER PULP*

By Conrad P. Straub

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Introduction

The results of single tests for ammonia and organic nitrogen made on composite samples from the final material drawn from digestion tanks fed pure paper pulp (as described in *This Journal*, September 1943) indicated that a decrease in the available nitrogen might have an effect upon the rate of digestion and the rate of gas production of paper pulp solids added to well-seeded, heated, separate sludge digestion tanks. In order to determine the extent of this effect, parallel studies were carried out using daily paper pulp feeds to which nitrogen was or was not added. Varying concentrations of paper pulp (0.5, 1.17, 1.83, and 2.5 lb. of total solids per cu. ft. of occupied tank space per month) were fed to each of two tanks. Nitrogen was added to one tank of each set of two receiving similar concentrations of paper pulp to give a carbon to nitrogen ratio of 20 approximating that of fresh raw sewage sludge. The results were correlated with data obtained from the operation of two control tanks which were fed fresh raw sewage sludge at the rate of 2.5 lb. of total solids per cu. ft. of occupied tank space per month.† At the start, ammonium sulfate ($(NH_4)_2SO_4$) was added but since this resulted in the production of odors, its use was abandoned and sodium nitrate ($NaNO_3$) was substituted.

Ten experimental digestion units similar to those previously described (1) were used in this study.

Procedure

The tanks were seeded with digested sludge in amounts shown in Table I. Fresh raw sewage sludge was first added to the tanks on October 14. Additions were continued according to the schedule given in Table II. Although no material was added to the tanks after April 27, they were operated until May 17. During this interval (April 27 to May 17) gas was measured and withdrawn.

Before paper pulp and sewage were added to the tanks, they were prepared as previously described (2).

* This is the third and last of a series of papers based on two years' research at Cornell University. The first paper appeared in the July 1943 issue of *This Journal*, p. 658, and the second in the September 1943 issue of *This Journal*, p. 857.

† By occupied tank space is meant the average space available in the tank for addition solids. It is the space occupied by the supernatant liquor and the sludge.

TABLE I.—*Date and Amount of Seed*

Tank	Date Seeded 1940	Amount of Digested Sludge Used for Seed, lbs.
16	Oct. 8	238.63
15	Oct. 8	244.89
14	Oct. 9	234.91
13	Oct. 9	239.93
12	Oct. 9	242.65
11	Oct. 9	245.65
10	Oct. 9	238.37
9	Oct. 11	240.10
8	Oct. 8	243.16
7	Oct. 8	242.33

TABLE II.—*Daily Feedings to Tanks*

Tank	Lbs. of Fresh Sludge Added Daily	Lbs. of Wet Pulp Added Daily	Jan. 13–Feb. 12	Feb. 13–Apr. 26
			$(NH_4)_2SO_4$, grams	$NaNO_3$, grams
16*	8.50	—	—	—
15*	8.50	—	—	—
14	—	0.22	—	—
13	—	0.22	4.53	5.64
12	—	0.51	—	—
11	—	0.51	10.57	13.16
10	—	0.81	—	—
9	—	0.81	16.61	20.65
8	—	1.10	—	—
7	—	1.10	22.65	28.20

* Controls.

Lime was added to all tanks receiving paper pulp with the exception of tanks 14 and 13 to maintain optimum pH conditions. The amount of lime used is given in Table III.

RESULTS OF TEST

Solids Characteristics.—A summary of the fresh sludge and paper pulp characteristics is given in Table IV and indicates considerable variation in the per cent total solids (wet basis) and in the per cent volatile solids (dry basis) of the fresh raw sludge added to the experimental digesters. There was much less variation in the paper pulp values. The hydrogen-ion content of the fresh raw sludge was fairly constant.

The amounts of ammonium sulfate, sodium nitrate, and lime added to each tank are shown in Table III.

Table V presents the supernatant liquor characteristics of all the tanks receiving sewage sludge and sewage sludge followed by pure paper pulp feedings with and without the addition of nitrogen in the form of ammonium sulfate or sodium nitrate. In all tanks the per cent total solids (wet basis) removed were lower after the additions of paper pulp than the per cent total solids (wet basis) removed from tanks to

TABLE III

SUMMARY OF MATERIALS ADDED TO OR REMOVED FROM TANK

	Tank 15 (a)		Tank 16 (a)		Tank 14 (a)		Tank 13 (a)		Tank 12 (a)		Tank 11 (a)		Tank 10 (a)		Tank 9 (a)		Tank 8 (a)		Tank 7 (a)	
	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs	Total added to or removed in lbs	Daily added to or removed in lbs
Seed Material lbs	239.63	8.553	244.89	9.417	234.9	7.484	239.98	8.254	242.65	9.197	245.65	8.300	238.37	7.980	240.0	7.927	241.6	8.558	242.39	9.064
Daily Loadings lbs																				
Fresh sewage sludge	53.0	33.333	53.0	33.333	59.7.0	5.361	59.7.0	6.536	59.7.0	6.536	59.7.0	6.536	59.7.0	6.536	59.7.0	6.536	59.7.0	6.536	59.7.0	6.536
Paper pulp					6905	5.145	6905	5.381	39.08	6928	34.98	6928	22.25	6.095	62.23	9.095	84.34	25.802	84.34	25.802
Chemical																				
$(NH_4)_2SO_4$							0.140				2.327				0.513				0.780	
$NaNO_3$							0.159				1.772				2.780				3.500	
Lime								1.983			2.397		1.983		1.983		2.980		1.983	
Withdrawals																				
Supernatants																				
Fresh sludge supernatants	56574	0.812	75.47	0.739	5890	0.319	3330	0.334	1057	1.0436	6.93	2.486	39.06	0.2356	3541	0.430	34.29	0.265	112.61	0.2569
Composite supernatants *					58.93	0.146	43.90	0.123	2688	7.029	425.76	2.022	379.47	0.441	350.89	0.531	478.23	0.684	516.33	1.031
Digested Sludges																				
Digested sewage sludge	3421	7.896	2845	8.220	5947	4.009	8137	4.615	14083	4.542	3074	3.420	6313	4.240	4019	3.087	4760	4.426	4263	4.469
Composite sludges *					3526	.058	3320	.0800	3275	.1020	3006	.0749	4057	.1304	3167	.269	3533	.287	3610	.378
Emptying Tanks																				
Composite sludges *	3105	8.140	3905	8.896	4250	5.022	4562	5.893	4934	6.82	5802	3.356	5704	.0373	5232	4.120	4942	9.782	4496	4.607
Unaccounted solids - lbs	24780		24647		17376		16958		21832		23928		24036		22021		22389		27682	
Gas produced/in cu ft	383.11		396.40		241.02		243.13		286.32		293.30		333.08		334.39		331.56		328.63	
Cu ft gas per lb volatile material unaccounted for	15.46		16.08		13.87		14.35		13.11		12.26		13.87		12.5		15.34		11.87	
Lbs of solids added per cu ft tank space per mo	2.5		2.5		0.5		0.5		1.167		1.167		1.833		1.833		2.5		2.5	
Number additions to tanks																				
Sewage sludge	150		150		75		75		75		75		75		75		75		75	
Paper pulp					75		75		75		75		75		75		75		75	

(a) Wet weight
(b) Dry weight
* Mixed Sewage Sewage Sludge

which fresh raw sludge was added. The per cent total solids (wet basis) removed from the tanks were higher in all cases in the tanks receiving nitrogen along with the pulp than in the other tanks receiving only paper pulp. Tank 7 which received nitrogen with the pulp was an exception to this. The per cent volatile solids (dry basis) were higher than the control values for tanks receiving no chemical, and lower for those tanks receiving chemical (possibly due to the solution of chemical giving a higher non-volatile solids content). The pH's of the supernatant liquor in the tanks receiving chemical were higher than in those receiving paper pulp alone.

Table VI presents the digested sludge characteristics of all digested solids withdrawn from the tanks. There was some variation in the per cent total solids (wet basis) but this was due primarily to the manner in which the material was withdrawn from the tanks and to the amount withdrawn at any one time. Less variation was noted in the per cent volatile solids (dry weight) values. The pH values (on the basis of the few tests made) seem to be generally higher for the tanks whose feeds were supplemented with nitrogen.

Table VII summarizes the characteristics of the final sludge withdrawn from the tanks at the end of the investigation. In general, there

was an increase in the per cent volatile solids (dry basis) values with an increase in paper pulp feeds. However, those tanks receiving chemical had lower volatile solids contents throughout than corresponding tanks receiving no chemical. With the exception of tank 13, the pH values for those tanks receiving chemical were higher than those receiving pulp alone.

Table VIII presents data taken from Table III which permit the computation of the reduction in weight of volatile material in each tank. The reduction was dependent upon the time allotted for digestion. Since the time for digestion after discontinuance of loading was short (two weeks), the values obtained were variable and were not in agreement with those reported for the first year's work (2) where the time of digestion after cessation of loading was much longer. The values reported in Table VIII indicate, in general, that greater reductions in the weight of volatile material were obtained in those tanks to which nitrogen was added. A study of the data presented in Table VII also substantiates this.

TABLE IV.—*Characteristics of Materials Added to Tanks*

Tank	Mat'l.	No. Samp.	Total Solids (% wet basis)			Volatile Solids (% dry basis)			Volatile Solids (% wet basis)			pH		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
16	Raw	150	3.27	8.27	1.09	79.68	94.66	16.79	2.606	7.147	0.803	5.82	6.1	5.2
15	Raw	150	3.27	8.27	1.09	79.68	94.66	16.79	2.606	7.147	0.803	5.82	6.1	5.2
14	Raw	71	3.18	8.27	1.09	80.65	94.66	16.79	2.565	7.147	0.803	5.42	6.1	5.2
14	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
13	Raw	71	3.18	8.27	1.09	80.65	94.66	16.79	2.565	7.147	0.803	5.42	6.1	5.2
13*	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
12	Raw	71	3.16	8.27	1.09	80.79	94.66	16.79	2.553	7.147	0.803	5.42	6.1	5.2
12	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
11	Raw	71	3.16	8.27	1.09	80.79	94.66	16.79	2.553	7.147	0.803	5.42	6.1	5.2
11*	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
10	Raw	71	3.16	8.27	1.09	80.79	94.66	16.79	2.553	7.147	0.803	5.42	6.1	5.2
10	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
9	Raw	71	2.99	7.55	0.86	81.17	94.66	16.79	2.427	7.147	0.682	5.42	6.1	5.2
9*	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
8	Raw	71	3.01	7.55	0.86	81.20	94.66	16.79	2.444	7.147	0.682	5.42	6.1	5.2
8	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			
7	Raw	71	3.01	7.55	0.86	81.20	94.66	16.79	2.444	7.147	0.682	5.42	6.1	5.2
7*	Pulp	75	30.85	48.43	10.43	99.23	99.89	70.01	30.612	48.275	10.354			

* Chemical added to these tanks ($(NH_4)_2SO_4$ and $NaNO_3$).

TABLE V.—*Supernatant Characteristics*

Tank	No. Samp. Tested	Total Solids (% wet basis)			Volatile Solids (% dry basis)			Volatile Solids (% wet basis)			pH		
		Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
16	17	0.30	1.04	0.17	51.98	70.42	42.00	0.156	0.578	0.080	7.05	7.2	6.9[1]
15	17	0.27	0.47	0.15	48.17	56.10	40.30	0.132	0.250	0.061	7.11	7.3	6.9[1]
14	6	0.42	0.90	0.19	49.52	54.02	41.55	0.216	0.486	0.079	7.05	7.2	6.9[2]
14*	7	0.18	0.24	0.16	52.85	65.16	44.92	0.097	0.132	0.072	6.87	7.1	6.7[3]
13	6	0.43	1.12	0.19	49.77	55.79	43.13	0.223	0.625	0.082	7.08	7.2	6.95[2]
13†	7	0.21	0.25	0.18	40.84	49.86	25.86	0.084	0.111	0.059	6.97	7.12	6.8[3]
12	6	0.58	1.97	0.19	54.89	56.67	53.68	0.319	1.083	0.077	7.02	7.10	6.95[2]
12*	10	0.20	0.22	0.14	53.83	61.06	49.69	0.106	0.126	0.085	6.86	7.15	6.70[4]
11	5	0.79	2.89	0.19	45.04	54.16	17.66	0.212	0.510	0.097	7.10[5]	—	—
11†	10	0.29	0.31	0.25	34.96	53.87	7.58	0.102	0.156	0.021	7.14	7.25	6.97[6]
10	6	0.58	2.12	0.20	43.84	53.18	13.11	0.162	0.278	0.088	7.05	7.15	6.95[2]
10*	11	0.23	0.48	0.19	54.57	60.89	45.71	0.128	0.263	0.091	6.91	7.30	6.60[4]
9	6	0.57	2.15	0.19	50.98	55.52	44.60	0.306	1.194	0.085	7.00	7.1	6.9[2]
9†	12	0.33	0.46	0.22	46.88	59.77	29.36	0.148	0.198	0.122	6.97	7.49	6.65[7]
8	6	0.38	0.98	0.19	51.30	52.64	49.34	0.196	0.516	0.094	7.00	7.1	6.9[2]
8*	15	0.24	0.34	0.20	60.00	76.09	53.18	0.147	0.218	0.116	6.72	7.00	6.5[1]
7	6	0.43	1.12	0.21	50.97	54.88	44.99	0.225	0.615	0.095	7.02	7.10	6.95[2]
7†	13	0.43	0.73	0.25	46.52	62.08	28.13	0.198	0.440	0.137	6.93	7.20	6.80[3]

* After addition of paper pulp.

† After addition of paper pulp and chemical ($NaNO_3$ and $(NH_4)_2SO_4$).

[1] 8 tests for pH.
[2] 2 tests for pH.
[3] 4 tests for pH.
[4] 5 tests for pH.
[5] 1 test for pH.
[6] 3 tests for pH.
[7] 6 tests for pH.

Gas Characteristics.—Figure 1 shows the cumulative gas volumes produced during the period of the investigation plotted against time. Before plotting, all gas volumes were reduced to standard conditions (0° and 760 mm.). The volumes reported were lower than those that would normally be obtained in practice because the gas was collected over water, and some losses resulted due to the solubility of the gases. Gas production was a function of the tank loading.

A comparison of the amount of gas produced per lb. of volatile solids unaccounted for or consumed during 1939–40 and 1940–41 in the control tanks is given in Table IX.

From the data given in Table III one can see that with the exception of tank 13, all tanks receiving nitrogen produced less gas per lb. of pulp consumed than did the corresponding tanks in each series which received no nitrogen. This would indicate that nitrogen in the amounts added to the tanks had a detrimental effect on the amount of gas produced per lb. of volatile solids consumed. This is shown graphically in Fig. 2.

TABLE VI.—*Digested Sludge Characteristics*

Tank	No. Samp. Tested	Total Solids (% wet basis)			Volatile Solids (% dry basis)			Volatile Solids (% wet basis)			pH		
		Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
16	12	4.44	5.98	3.62	55.92	58.68	54.04	2.486	3.369	2.040	6.96	7.17	6.75[1]
15	11	5.42	6.74	3.48	56.91	60.98	54.97	2.930	3.518	1.997	6.91	7.10	6.74[1]
14	5	4.38	5.17	4.16	56.47	57.24	54.79	2.472	2.833	2.381	7.0[2]	—	—
14*	2	5.20	5.23	5.16	57.37	57.92	56.82	2.980	3.029	2.932	6.77[2]	—	—
13	5	4.52	6.11	3.88	55.76	57.16	53.62	2.514	3.276	2.218	7.05[2]	—	—
13†	2	4.28	4.69	3.88	55.20	57.16	53.23	2.357	2.496	2.218	7.02[2]	—	—
12	5	5.87	6.15	5.72	54.99	55.33	53.78	3.225	3.307	3.157	7.0[2]	—	—
12*	2	5.79	6.03	5.55	55.72	56.66	54.79	3.229	3.417	3.041	7.2[2]	—	—
11	5	4.88	5.38	4.73	56.25	57.85	53.10	2.543	2.857	2.405	7.1[2]	—	—
11†	2	4.45	4.84	4.06	57.50	60.42	54.58	2.548	2.642	2.453	6.99[2]	—	—
10	5	4.76	5.99	4.37	56.30	57.69	52.16	2.681	3.369	2.279	6.95[2]	—	—
10*	2	6.21	6.43	5.99	55.00	56.25	53.74	3.412	3.455	3.369	7.62[2]	—	—
9	5	5.36	6.23	4.88	55.32	57.16	54.65	2.964	3.458	2.789	6.95[2]	—	—
9†	2	7.02	7.81	6.23	54.58	55.51	53.65	3.824	4.190	3.458	8.42[2]	—	—
8	5	5.51	5.87	5.34	56.48	57.22	53.62	3.115	3.354	3.040	7.0[2]	—	—
8*	2	6.29	6.71	5.87	56.06	57.14	54.99	3.522	3.690	3.354	7.31[2]	—	—
7	5	5.69	5.84	5.65	55.60	56.60	52.46	3.162	3.198	3.064	7.0[2]	—	—
7†	2	6.44	7.22	5.65	56.14	56.60	55.68	3.609	4.020	3.198	8.16[2]	—	—

* After addition of paper pulp.

† After addition of paper pulp and chemical ($NaNO_3$ and $(NH_4)_2SO_4$).

[1] 4 tests for pH. [2] 1 test for pH.

TABLE VII.—*Characteristics of Material Removed from Tanks at End of Test*

Tank	No. Samp. Tested	Total Solids (% wet basis)			Volatile Solids (% dry basis)			Volatile Solids (% wet basis)			pH		
		Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
16	5	3.77	7.32	1.24	52.77	60.14	41.91	2.003	4.402	0.520			
15	5	4.03	7.96	0.46	54.46	59.65	45.99	2.238	4.070	0.212			
14	5	2.09	5.84	0.21	57.86	67.20	44.70	1.172	3.488	0.141	7.42	7.66	7.22[1]
13*	5	2.73	7.50	0.29	46.65	56.41	33.07	1.423	3.884	0.096	7.24	7.36	7.13[1]
12	6	2.79	6.35	0.31	55.90	60.91	46.84	1.630	3.868	0.183	7.02	7.26	6.60[1]
11*	7	1.96	6.69	0.35	50.56	62.71	34.03	1.070	3.806	0.119	7.14	7.43	6.58[2]
10	7	3.21	7.57	0.70	59.52	69.97	55.19	1.925	4.357	0.386	6.98	7.80	6.50[2]
9*	7	3.67	7.95	0.83	58.87	84.69	47.52	2.452	6.733	0.422	7.56	7.92	7.27[2]
8	8	4.40	8.86	1.01	64.79	76.26	54.96	2.956	6.024	0.589	6.98	7.48	6.57[2]
7*	8	3.69	7.81	1.51	60.22	77.89	46.40	2.247	4.327	0.701	7.01	7.65	6.18[2]

* Chemical added to these tanks. [1] 4 tests for pH. [2] 6 tests for pH.

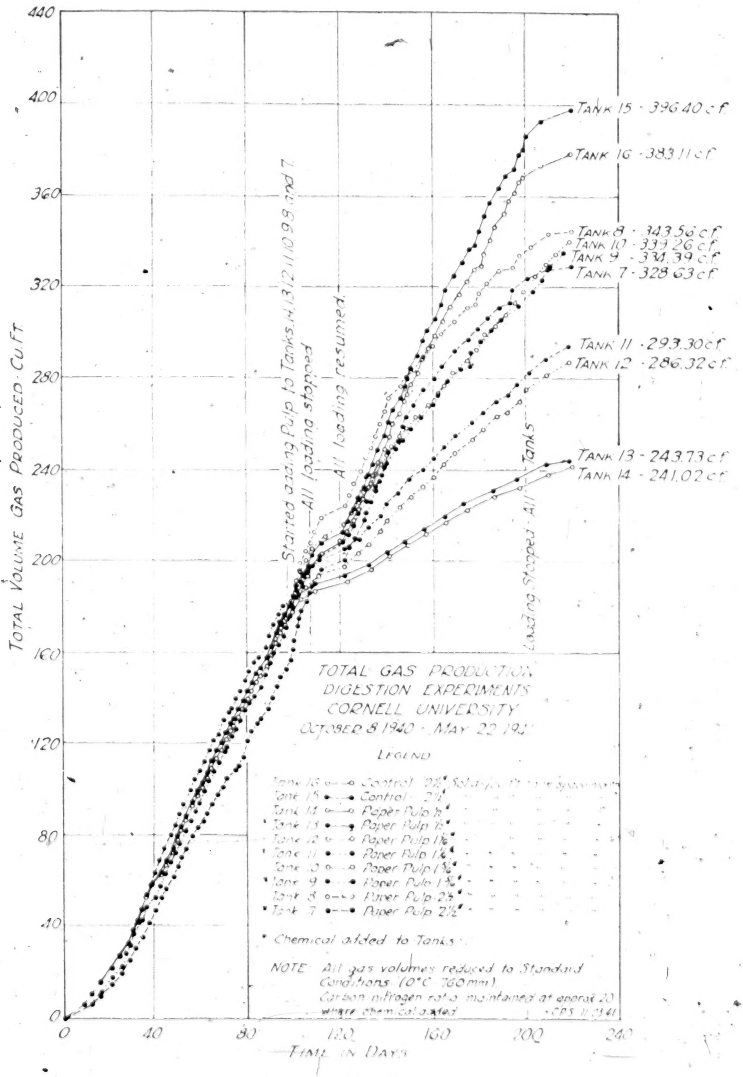
TOTAL VOLUME GAS PRODUCED · CU. FT.
TIME IN DAYS
TANK 15 - 396.40 c.f.
TANK 16 - 383.11 c.f.
TANK 8 - 343.56 c.f.
TANK 10 - 339.26 c.f.
TANK 9 - 334.39 c.f.
TANK 7 - 328.63 c.f.
TANK 11 - 293.30 c.f.
TANK 12 - 286.32 c.f.
TANK 13 - 243.73 c.f.
TANK 14 - 241.02 c.f.
Started adding Pulp to Tanks 14, 13, 12, 11, 10, 9, 8 and 7.
All loading stopped
All loading resumed.
Loading Stopped - All Tanks
TOTAL GAS PRODUCTION
DIGESTION EXPERIMENTS
CORNELL UNIVERSITY
OCTOBER 8 1940 - MAY 22 1941
LEGEND
Tank 16 Control 2½
Tank 15 Control 2½
Tank 14 Paper Pulp ½
Tank 13 Paper Pulp ½
Tank 12 Paper Pulp 1¼
Tank 11 Paper Pulp 1¼
Tank 10 Paper Pulp 1¾
Tank 9 Paper Pulp 1¾
Tank 8 Paper Pulp 2½
Tank 7 Paper Pulp 2½
* Chemical added to Tanks
NOTE: All gas volumes reduced to Standard Conditions (0°C 760 mm)
Carbon nitrogen ratio maintained at approx 20 where chemical added
CPS 11 23 41

FIG. 1.

TABLE VIII.—*Per Cent Reduction in Weight of Volatile Sludge Solids*

Tank	$a - b - c$*	$a - b$*	a	% Reduction	
				$\frac{a-b-c}{a-b} \times 100$	$\frac{a-b-c}{a} \times 100$
16	24.780	32.920	41.626	75.27	59.52 Control
15	24.647	33.563	42.512	73.44	57.98 Control
14	17.376	22.398	27.990	77.58	62.08
13†	16.988	22.881	28.753	74.25	59.08
12	21.832	30.014	36.323	72.74	60.11
11†	23.928	30.284	35.426	79.01	67.54
10	24.996	35.969	42.280	69.49	59.12
9†	26.724	40.844	47.181	65.43	56.64
8	22.389	42.171	48.835	53.09	45.85
7†	27.682	42.284	49.418	65.47	56.02

† Chemical added to these tanks.

* a = seed + sewage sludge + pulp added in lbs.
b = digested sludge + supernatant withdrawn in lbs.
c = amount withdrawn at end of test in lbs.
All weights are those of volatile dry solids.

Figure 3 is a plot of the total amount of gas produced in cu. ft. versus lb. of volatile material present in the tank. For a description of the method used in plotting these curves, see the first two papers (1, 2) of this series. If the last plotted point of each curve is connected with the origin, the slope of this line is equal to the quantity of gas produced in cu. ft. per lb. of solids consumed. These values are tabulated in Table III.

TABLE IX.—*Gas Production* in Control Tanks*

Tank	1939-40	1940-41
16	15.98	15.46
15	14.63	16.08
Average	15.30	15.77
Average for 2 yr. period	15.54	

* Cubic feet of gas produced per pound of volatile solids unaccounted for or consumed.

In Table X are given analyses of gas samples collected at various intervals during the investigation. From the data obtained in the analyses of the few samples, we can see that there was less methane in the gas from those tanks to which paper pulp was added than in the controls. Likewise, there was less methane in those tanks receiving nitrogen than in the complementary tank of each series. There seems to be no such marked difference in the carbon dioxide content of the gas. However, there was more nitrogen gas in those tanks receiving nitrogen than in the others; the amount of nitrogen increasing with an increase in nitrogen loading.

Ammonia and Organic Nitrogen.—Table XI presents the results of ammonia and organic nitrogen determinations made at various times

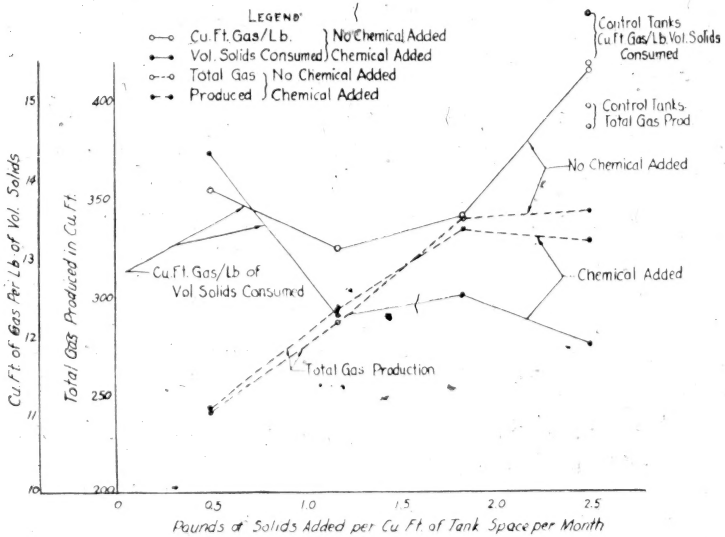

FIG. 2.

TABLE X.—*Results of Gas Analyses*

Tank	No. Sample	CH_4	H_2	CO_2	O_2	CO	N_2
16	10	67.7	1.1	27.4	0.1	0.1	3.6
15	10	66.9	1.7	27.6	0.2	0.1	3.5
14	1	69.1	4.2	26.4	0	0	0.3
14*	3	59.4	0.6	35.2	0.2	0.4	4.5
13	3	68.5	0.8	27.1	0.2	0.1	3.2
13†	3	53.8	2.8	35.3	0.2	0	7.9
12	1	70.3	0	26.2	0.2	0	2.9
12*	7	61.3	0.6	34.2	0.3	0.1	3.5
11	1	70.8	0	26.2	0.3	0.3	2.4
11†	6	56.2	1.2	34.8	0.2	0.1	7.4
10	1	67.9	1.6	26.8	0.2	0.1	3.4
10*	3	58.9	1.2	35.5	0.2	0.1	4.3
9	1	68.1	0	27.4	0.2	0.1	4.2
9†	4	57.2	0.5	36.0	0.3	0.1	6.0
8	1	67.6	0	25.8	0.6	0.1	5.9
8*	4	61.0	3.8	32.6	0.4	0.1	2.1
7	1	68.2	1.3	26.1	0	0	4.4
7†	7	51.0	1.6	38.8	0.2	tr.	8.4

* After addition of paper pulp. † After addition of paper pulp and chemical.

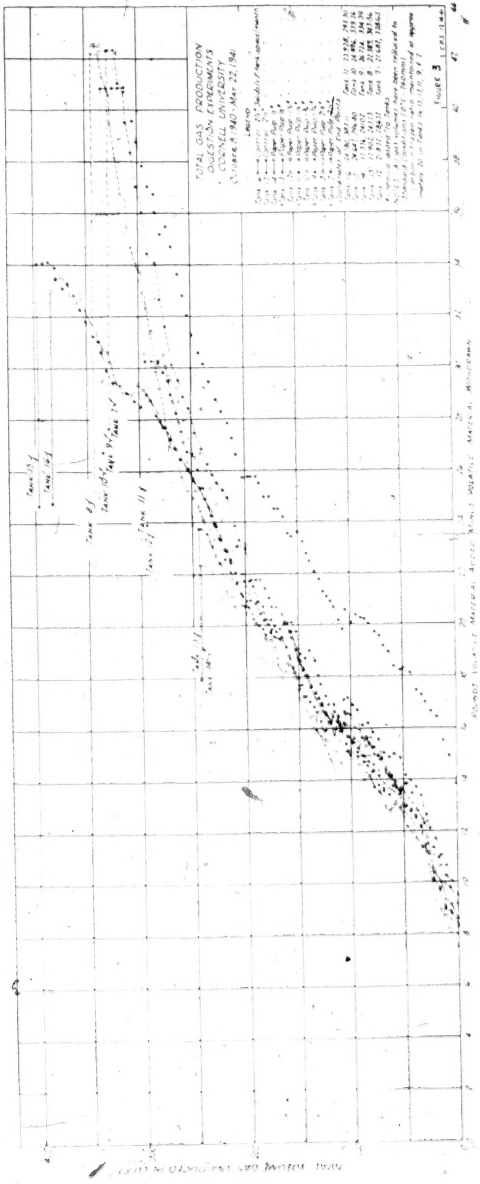
TOTAL GAS PRODUCTION
DIGESTION EXPERIMENTS
CORNELL UNIVERSITY
OCTOBER 8, 1940 - MAY 22, 1941
LEGEND
FIGURE 3
POUNDS VOLATILE MATERIAL ADDED MINUS VOLATILE MATERIAL WITHDRAWN
TOTAL VOLUME GAS PRODUCED IN CUBIC

FIG. 3.

TABLE XI.—*Nitrogen Test Results*

Tank	Sample	Date	Ammonia Nitrogen, p.p.m.	Organic Nitrogen, p.p.m.	Total Nitrogen, p.p.m.
7	Super.*	3/18/41	1,530	0	1,530
7	Super.	4/15/41	750	600	1,350
7	Dig.†	3/28/41	2,800	20,800	23,600
7	Final‡	5/25/41	400	10,000	10,400
8	Super.	3/18/41	40	0	40
8	Dig.	3/28/41	1,700	0	1,700
8	Super.	4/15/41	100	152	252
8	Final	5/25/41	202	9,200	9,402
9	Super.	3/18/41	900	550	1,450
9	Dig.	3/28/41	5,000	11,600	16,600
9	Super.	4/15/41	1,200	360	1,560
9	Final	5/25/41	304	8,800	9,104
9	Final	5/25/41	1,220	8,000	9,220
10	Super.	3/18/41	240	0	240
10	Dig.	3/28/41	2,760	19,200	21,960
10	Super.	4/15/41	880	0	880
10	Final	5/25/41	200	8,800	9,000
10	Final	5/25/41	50	4,200	4,250
10	Final	5/25/41	640	9,500	10,140
11	Dig.	3/31/41	1,680	10,800	12,480
11	Super.	4/15/41	2,620	0	2,620
11	Final	5/25/41	1,910	6,000	7,910
11	Final	5/25/41	400	6,450	6,850
11	Final	5/25/41	600	4,150	4,750
12	Dig.	3/11/41	2,860	13,200	16,060
12	Super.	4/15/41	3,360	300	3,660
12	Final	5/25/41	100		
12	Final	5/25/41	200	2,130	2,330
13	Dig.	3/31/41	4,600	13,600	18,200
13	Final	5/25/41	3,000		
13	Final	5/25/41	2,400		
13	Final	5/25/41	6,150	10,900	17,050
14	Dig.	4/ 1/41	1,200	17,600	21,800
14	Final	5/25/41	2,700	8,350	11,050
14	Final	5/25/41	2,360	10,200	12,560
14	Final	5/25/41	2,330	975	3,305
14	Final	5/25/41	2,310	1,010	3,320
15	Dig.	4/ 1/41	4,040	8,000	12,040
15	Super.	4/15/41	3,360	80	3,440
16	Dig.	4/ 1/41	3,800	13,200	17,000
16	Super.	4/15/41	1,200	200	1,400

* Supernatant liquor. † Digested sludge. ‡ Final sludge withdrawn.

throughout the investigation on samples withdrawn from the tanks. These limited data indicate that in tanks 7 and 9 of the series 7 and 8 and the series 9 and 10, the supernatant liquor, digested and final sludges had higher total and organic nitrogen contents than did tanks 8 and 10. The odd numbered tanks received the sodium nitrate. In considering tanks 11 and 12 and tanks 13 and 14, the data reveal that total nitrogen values were higher for supernatant liquor and digested sludge in tanks 11 and 13 and lower for the nitrogen contents for the final sludge.

Conclusion

The following conclusions may be drawn from the data presented:

1. Because hydrogen sulfide was produced when ammonium sulfate was added to the tanks, its use was abandoned at the end of one month. No conclusions are made on the use of this chemical because of the short period of its use.

2. Sodium nitrate, which was added after ammonium nitrate was abandoned, reduced the amount of gas produced in cu. ft. per lb. of volatile solids consumed.

3. Less methane and more nitrogen gas * were produced in those tanks receiving sodium nitrate.

4. In general, a more complete breakdown of volatile solids resulted in those tanks receiving sodium nitrate.

5. It was necessary to add lime to the tanks to maintain satisfactory pH conditions. However, less lime was required in those tanks receiving the sodium nitrate.

In summary, sodium nitrate had a decided effect on the digestion of paper pulp in that it reduced the rate of gas production, reduced the methane content, increased the nitrogen * content of the gas, and caused, in general, a more complete breakdown of the volatile solids.

Acknowledgment

The author acknowledges his indebtedness to Professor C. L. Walker of Cornell University for his consultation in this work and to Mr. F. W. Montenari, former graduate student, who assisted the writer in a number of ways.

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* The per cent nitrogen is taken as the difference between the sum of the per cents of methane, carbon dioxide, oxygen, hydrogen, and carbon monoxide, and 100 per cent.

LONGITUDINAL MIXING IN AERATION TANKS

By Harold A. Thomas, Jr.,* and Jack E. McKee†

Foremost among the desirable characteristics of aeration tanks are *uniformity* and *efficiency* of mixing. Uniform turbulence is conducive to homogeneity of treatment; efficient aeration is requisite to economy of operation. The introduction of spiral flow has brought about a very efficient utilization of the energy of aeration, but it is only with careful design that this energy is distributed uniformly over the entire cross section of the tank. While the peripheral velocities are high and are conducive to efficient mixing and aeration, there may be only small energy dissipation in the central region of the cross section. This central quiescence is undesirable for two reasons: (1) under unfavorable circumstances, it may preclude proper oxidation, and (2) it may cause short circuiting.

While the effects of improper oxidation are generally recognized, the nature of short circuiting is less perfectly understood. The root of the difficulty lies with the use of the term "short circuiting" in a hydrodynamic sense. The meaning of the term is specific. Certain particles travel through the tank in a shorter time than others by virtue of greater velocities and less circuitous paths. The mechanism by which this movement occurs requires elaboration, since, paradoxically, short circuiting is favored by both turbulence and quiescence. With a high degree of peripheral turbulence a rapid longitudinal mixing takes place, so that some particles travel the length of the tank in a very short time at the expense of other particles that must take a correspondingly longer time. On the other hand the particles in a quiescent core travel without deviation along the shortest route to the effluent if no transfer to the turbulent periphery takes place. Unless proper precautions are taken, plants employing spiral flow are prone to short circuiting with the concomitant evils of undertreatment and rapid passage of some of the mixed liquor, possibly including pathogenic organisms.

Studies by Hurd (1), Calvert and Bloodgood (2), Freese (3) and others have shown that short circuiting may be overcome by proper design. Of particular importance in the uniform distribution of turbulence are the shape of cross section and location of diffusers or paddles. This phase of design is sufficiently developed so that a reasonable uniformity of turbulence over the cross section may be obtained. In addition, there has been a widespread use of transverse baffles which are effective in preventing direct short circuiting.

Most of the investigations of mixing in aeration tanks have been full-scale field experiments with particular application to certain plants. While there can be no doubt as to the utility of these investigations, the approach has been essentially empirical. Consequently, it has been difficult to apply the results obtained at one plant to another operating under

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differing circumstances. It would appear, therefore, that a more complete control of longitudinal mixing is dependent upon a more fundamental understanding of the process. Furthermore, with the continued development of the activated-sludge process, additional considerations have appeared that make such understanding increasingly advantageous.

The effects of longitudinal mixing assume added significance when it becomes necessary to treat shock loads or "slugs" of toxic, or septic wastes. In this circumstance a considerable amount of longitudinal mixing may be desirable in order to distribute the shock load evenly throughout the tank. Improper distribution of the load may result in depletion of the dissolved oxygen in the mixed liquor in the first part of the tank. In that event, too many baffles may prove disastrous. The problem of the design and arrangement of baffles, however, is far from being an exact science. An adequate theory of longitudinal mixing will furnish pertinent information as to the number and arrangement of baffles, and the degree to which they should constrict the flow.

Tapered aeration, while widely practiced, may not be indicated in many tanks subject to excessive longitudinal mixing or to distributed loading. The full development of the potentialities of tapered aeration, therefore, awaits a more complete generalization of the laws of longitudinal mixing. It is clearly evident that there is no advantage in reducing the air supply at the downstream end of an aeration tank if a substantial portion of the influent reaches this region a few minutes after entering the tank. Yet this short circuiting may readily obtain in a short tank without proper baffling.

The high degree turbulence in activated sludge aeration tanks allows some particles to travel upstream and downstream within the tank (or between baffles) many times before eventually being carried away in the effluent. As the mixed liquid passes over the diffuser plates and is caught in the upward draft of air, the kinetic energy of the liquid is increased, causing it to foam and churn at the surface while being directed horizontally and laterally across the tank. Although the horizontal lateral vector of velocity is increased, it is also apparent that the vectors causing motion upstream or downstream are also accelerated. Because these velocities are much greater than the rate of travel longitudinally through the tank, it is apparent that mixing as a result of agitation at the periphery of the spiral flow can take place readily, even counter-current to the principal direction of flow through the tank. At Indianapolis, for example, Calvert and Bloodgood (2) added sludge at any one of a number of points in the aeration tank in order to use the first part of the tanks for pre-aeration of sewage. They found that sludge added at the half-way point, 238 feet from the influent end, worked back in reducing concentrations to the influent end, counter-current to the flow of sewage through the tank.

An interesting and important application of the theory of mixing appears in the question of survival of pathogenic organisms, such as *Eberthella typhosa,* in aeration tanks. Laboratory studies have shown that the overwhelming majority of those pathogens die in the initial stages of the detention period. Should short circuiting cause some of the mixed

liquor to pass through the tank rapidly, it is evident that bacterial survival would be increased markedly.

An understanding of longitudinal mixing is important in the development of "step aeration" by Gould (4) or "distributed loading" by McKee and Fair (5) in which sewage is added to mixed liquor at various points along the tank. Short circuiting of the last increment of sewage added near the effluent end would favor the survival of pathogenic organisms. In that event, baffles may be used to control longitudinal mixing, but too many baffles may be undesirable, especially if they are spaced improperly.

The foregoing considerations indicate the importance of an investigation of the laws of longitudinal mixing in order that guiding principles may be developed relating to the design of aeration tanks.

Theoretical Analysis

Mixing Without Baffles.—Before a presentation of the theoretical analysis governing longitudinal mixing, attention is invited to a study, presented in Fig. 1, to show the manner in which a concentrated salt solution, introduced at the influent end of a laboratory aeration tank without baffles, was found to travel downstream. The concentration is plotted on the vertical axis as a quotient, u/u_d, equal to the measured concentration divided by the concentration that would have occurred if the initial salt dose had been distributed uniformly throughout the tank. The horizontal axis represents distance measured downstream as a fraction of the total distance or length of tank. Each curve shows the distribution of concentration for a given instant of time expressed as a ratio (t/D), where D is the computed theoretical detention period. Together these curves depict a tendency to flatten caused by longitudinal mixing and also a translation downstream with the flow. At $t/D = 0$, the curve of distribution would be the vertical axis; at infinite time, the horizontal axis.

Experiments by the authors and other investigators indicate a similar process in full-scale tanks. Since substantial experimental difficulties are encountered with actual tanks, the precision necessary for a fundamental study can be obtained more readily with models. Fortunately, the laws of similitude are definite and model tests can be made to indicate performance in large tanks.

Two processes are involved, namely, mixing and translation downstream. The essence of the problem, therefore, involves an explanation of the interaction of these processes on particles entering the tank.

The amount of salt passing any given transverse section of the tank, A, at the time, t, is equal to the amount flowing past by normal displacement plus and minus the amounts passing back and forth as the result of the mixing. The net transfer downstream due to mixing is proportional to the concentration gradient and the area of cross section of the tank. The total transfer of salt across the section may be expressed, therefore, as

$$Qu - b^2 A \frac{\partial u}{\partial x}.$$

Here Q is the discharge (vol./unit time); u, the concentration (wt./unit

vol.); b^2, a constant depending upon the degree of turbulence, called the "mixing constant" (length^2/unit time) derived by dimensional analysis; A, the area of cross section; and $\partial u/\partial x$ the concentration gradient. The value of the mixing constant, b^2, may be determined experimentally for an aeration system as follows: (*a*) by-pass the flow around the tank; (*b*) with the tank full of sewage or water and the aeration proceeding at the desired rate, add enough salt (NaCl) at one end to increase the chloride content 100 p.p.m. when finally distributed throughout the entire volume; (*c*) at the opposite end, collect samples at frequent regular intervals and determine chloride content; (*d*) from a graph of concentration vs. time ascertain the time required for the concentration at the opposite end to attain 90 per cent of its ultimate value; (*e*) the value of b^2 (ft.^{2}/hr.) may be obtained from the formula

$$b^2 = \frac{180l^2}{\pi^2 t_{90}},$$

where l is the length of the tank in feet, and t_{90}, the time in minutes, as obtained in step (*d*). This formula follows from equation (2) that is to be derived. If there are baffles in the tank, one or two of them must be temporarily extended to isolate a section in which the test may be conducted.

Derivation of Equation of Mixing.—Referring to the inserted sketch of Fig. 1, the increase in salt contained in an element of tank, dx, during the time, dt, equals the salt entering minus that leaving. Mathematically, this relationship may be stated as follows,

$$A \cdot dx \cdot dt \cdot \frac{\partial u}{\partial t} = dt\left[Qu - b^2 A \frac{\partial u}{\partial x}\right] - dt\left[\left(u + \frac{\partial u}{\partial x}dx\right)Q - b^2 A\left(\frac{\partial u}{\partial x} + \frac{\partial^2 u}{\partial x^2}dx\right)\right],$$

where the first bracket represents the influx of salt to the element and the second bracket, the loss. Noting that $Q = AV$, where V is the mean (displacement) velocity, and dividing by $dx \cdot dt \cdot A$, the differential equation of longitudinal mixing is obtained,

$$b^2 \frac{\partial^2 u}{\partial x^2} - V\frac{\partial u}{\partial x} = \frac{\partial u}{\partial t}. \qquad (1)$$

Applying the boundary conditions that (*a*) at $x = 0$, the gradient is proportional to the concentration and (*b*) at $x = l$, the gradient is zero, which followed from the fact that the velocity in influent and effluent pipes or weirs is much greater than V, then equation (1) may be integrated to give the following relation:

$$\frac{u}{u_d} = 2\sum_{n=1}^{\infty} \frac{a_n l e^{-k a_n^2 t + Bx}}{(a_n^2 + B^2)l + 2B}(a_n \cos a_n x + B \sin a_n x), \qquad (2)$$

where u = concentration at x and t; u_d = a constant = wt. of salt added ÷ vol. of tank; l = length of tank; $B = V/2b^2$; $a_1, a_2, a_3, \cdots, a_n$ = con-

stants given by the roots of the equation

$$\tan a_n l = \frac{2Ba_n}{a_n^2 - B^2},$$

$$k_n^2 = b^2[a_n^2 + B^2];$$

e = the base of Napierian logarithms.

Curves calculated from equation (2) are plotted in Fig. 1 along with experimental results obtained with a model tank eight feet long through

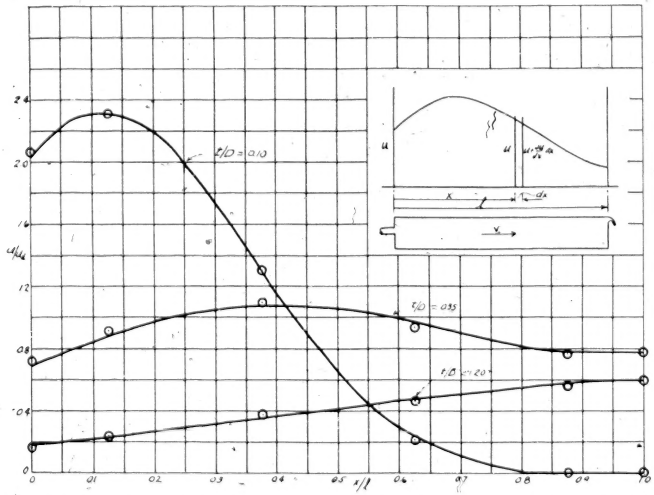

FIG. 1.—The effect of longitudinal mixing on the distribution of concentration, after various increments of time, of a salt solution applied at the upstream end of an aeration tank.

which a steady flow was maintained. Sodium chloride was added at the inlet and samples for titration were collected at regular intervals. Agitation was provided by an oscillating paddle extending over the length of the tank and operated at a rate such that the dimensionless factor $Vl/2b^2$ was 1.21. Results obtained with mechanical agitation did not differ essentially from those in which diffused air created the turbulence. However, in this phase of the research, careful control over the degree of agitation (b^2) was necessary, and for this purpose, mechanical agitation was found to be superior. Water rather than a sewage-sludge mixture was used after it was found that no significant difference existed between results with mixed liquor and with water. The profiles of concentration are shown in Fig. 1 at three different periods of time stated in terms of the detention period (D = vol. of tank ÷ Q). A number of other experiments on this tank and another somewhat larger one gave results that showed equally excellent agreement with the theoretical curves of equation (2), indicating the applicability of the formulation.

Of particular interest is the influence of longitudinal mixing upon the time of passage of the salt through the tank. In Fig. 2 are shown typical curves of concentration vs. time at $x = l$ for various values of $Vl/2b^2$. Excellent agreement with experiment is noted.

The quantity $Vl/2b^2$ is significant in that it combines in dimensionless form all the essential quantities in which aeration tanks without baffles can differ insofar as longitudinal mixing is concerned. That is, if the value of $Vl/2b^2$ is known for a tank without baffles, its mixing characteristics are completely determined. When the mixing constant, b^2, becomes very large in relation to the displacement velocity, V, the value of $Vl/2b^2$ approaches zero. This is the case of "perfect mixing" in which equation (2) reduces to the following simple form:

$$\frac{u}{u_d} = e^{-t/D}. \tag{3}$$

Equation (3) gives the exponential curve shown in Fig. 2 when the ratio,

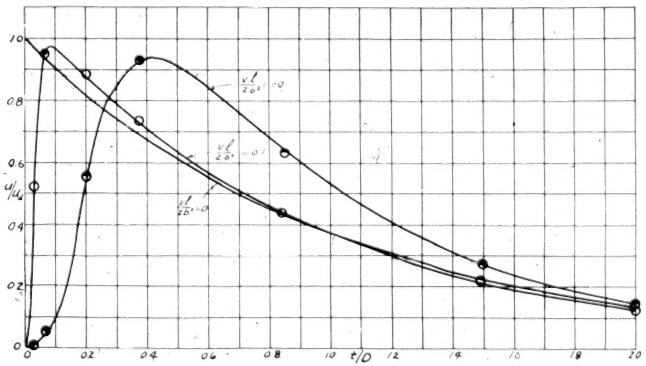

FIG. 2.—The effect of degree of agitation upon concentration of salt at the effluent end of the tank. For perfect mixing ($Vl/2b^2 = 0$) the concentration is instantaneously equalized throughout the tank at $u/u_d = 1$ and decreases exponentially as dilution progresses.

$Vl/2b^2 = 0$. Analyses of detention characteristics based upon the assumption of perfect mixing have frequently appeared in literature, being applied in an investigation reported by Kehr (6) in 1936. While this simplified formulation may render a satisfactory account of mixing in certain tanks, it has obvious limitations. In activated sludge aeration tanks the value of the ratio, $Vl/2b^2$, may be as high as or higher than 1.0; reference to Fig. 2 indicates clearly the invalidity of the assumption of perfect mixing in such instances.

Influence of Baffles.—From the foregoing analysis and experiments one striking fact is evident: a large portion of the flow passes through the tank in a relatively short time. This short circuiting occurs even with sizeable values of the ratio $Vl/2b^2$. A practicable method of reducing the portion flowing directly through the tank is the installation of one or more trans-

verse baffles with small openings so as to divide the tank into compartments. It is evident that the action of the baffle depends upon the size of the opening, for, if the flow is not restricted sufficiently, the turbulent surging back and forth may permit a considerable degree of mixing of the contents of adjacent compartments.

By dimensional analysis, together with other considerations in line with the theory underlying equation (2), it may be inferred that the action of a baffle is completely determined by a parameter including the velocity passing the baffle, the mixing constant, and a length characteristic. Such a parameter, M, is defined as follows:

$$M = \frac{b^2}{V_b h} \tag{4}$$

where V_b = velocity passing baffle = $Q \div$ area of opening at the baffle (ft./hr.); h = a length characteristic related to the dimensions of the baffle at the opening (ft.); b^2 = the "mixing constant," reflecting the degree of turbulence (ft.^{2}/hr.).

In order to formulate more precisely the influence of baffles upon longitudinal mixing, it will suffice to consider two chambers separated by a single baffle and to assume for simplicity that perfect mixing takes place so that the concentrations, u and u', are functions of time, but not of position (see sketch in Fig. 3). Then in each chamber, the change in the

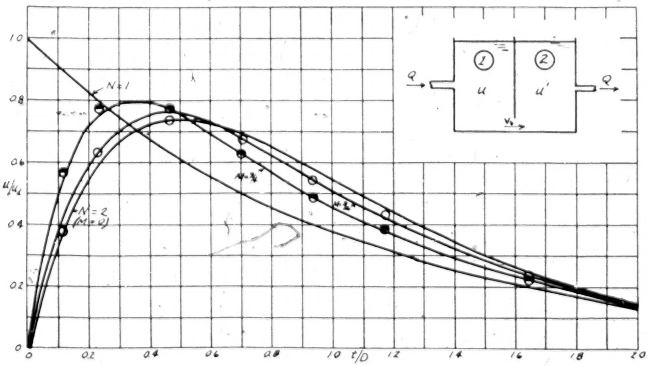

FIG. 3.—Theoretical and experimental representation of the effect of one baffle on the effluent concentration resulting from an instantaneous concentrated dose of salt at the influent end. Retention characteristics are dependent upon a parameter, M, determined by the size of opening, mixing constant, and velocity passing baffle.

amount of salt per unit time equals the quantity entering minus the quantity leaving, including the net amount passing the baffle as a result of the turbulent surging. Thus, after an initial concentrated dose is added to the upstream chamber, No. 1, the following relations apply:

For chamber No. 1,

$$V' \frac{du}{dt} = -Qu - QM(u - u') \tag{5}$$

and for Chamber No. 2,

$$V' \frac{du'}{dt} = -V' \frac{du}{dt} - Qu', \tag{6}$$

where $2V'$ is the volume of the entire tank. Equations (5) and (6) may be integrated to yield the following equation expressing the effluent concentration, u', as a function of t and the parameter M (equation 4):

$$\frac{u'}{u_0} = 2\sqrt{\frac{1+M}{M}}\, e^{-(t/D)(M+1)} \sinh 2\sqrt{M(M+1)}\,(t/D), \tag{7}$$

where D is the detention period for the entire tank $= 2V' \div Q$. Equation (7) is plotted in Fig. 3 in which experimental points obtained in a model tank using air diffusion are shown for values of M equal to 3/4 and 3/16. An increase in the factor M, which occurs when the area of baffle opening or turbulence is increased or the discharge decreased, brings about an increase in the degree of short circuiting. The variation takes place within the limits defined by the curves in Fig. 3, marked $N = 1$ and $N = 2$. The first of these, $N = 1$, represents the case when there is no baffle (equation 3); the second, $N = 2$, is approached as a limiting case as the opening in the baffle is made very small ($M = 0$). For convenience, this hypothetical case is called "perfect baffling."

From Fig. 3 and the underlying theory, certain deductions relative to the design of baffles become evident. It would appear that if M is less than, say 0.15, the mixing between chambers is substantially that achieved with perfect baffling. With values of b^2 and h occurring in activated sludge aeration tanks, which may be determined from the application of equations (2) and (7) to field data, it is possible by means of equation (4) to arrive at a value of V_b and therefore the degree of constriction that is required to obtain essentially perfect baffling. Average values of b^2/h in practice range from 1,500 to 5,000 ft. hr.; hence, V_b should be 3–10 ft. sec. Since design values are often much less than this figure, the baffling action produced is not complete. Some mixing may take place across the baffle. In many situations, the foregoing analysis would indicate that an appreciable head loss (0.25 to 1.0 ft.) across the baffle is necessary in order to secure nearly perfect baffle action. Since this hydraulic loss is likely to be undesirable, it may be advisable to install additional baffles, each with only a small loss. Kessener (7) investigated the passage of salt through an activated sludge aeration tank to which an initial concentrated dose was added to the first of a series of three equal chambers of 48 cubic meters each. His data are reproduced in part in Fig. 4, in which the plotted points refer to the concentration at various times at the baffle separating the first and second chambers (Kessener's curve 3). A theoretical curve assuming perfect baffling and $Vl/2b^2 = 0.1$ has been included in Fig. 4. Rather than introduce the additional discrepancy between theory and experiment entailed in the assumption of perfect mixing, a value of $Vl/2b^2$ was selected so as to make the first part of the theoretical curve approximate the data. This procedure is reasonable in absence of other informa-

tion regarding the turbulence since the first part of the curve is not influenced measurably by the characteristics of the baffles. It is apparent from Fig. 4 that the baffling action was far from complete and a considerable exchange of salt took place back and forth between the chambers.

The conclusion may be drawn that analysis of the mixing characteristics, assuming perfect mixing and baffling, may lead to marked error. However, for short chambers with much turbulence and separated by baffles with small openings, these assumptions yield a theory that for many purposes gives an adequate representation of mixing characteristics. The

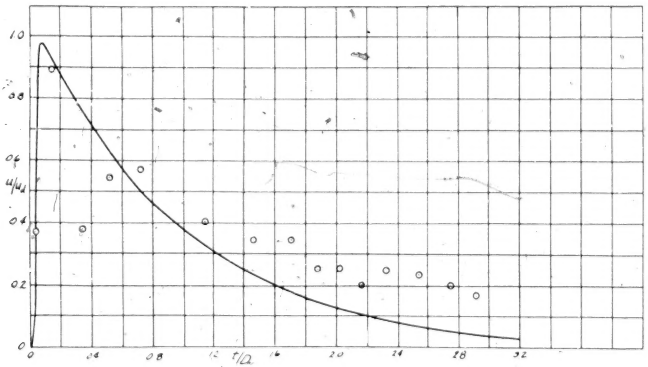

FIG. 4.—Data derived from experiments by Kessener (7) for an aeration tank of three equal chambers. The theoretical curve was selected to make the first part of the curve approximate the data.

fundamental equation (2) may be modified as follows to apply to a tank with a number of baffles and with perfect mixing and baffle action:

$$\frac{u}{u_d} = \frac{N^N}{(N-1)!} \cdot t^{N-1} \cdot e^{-N(t/D)} \quad \ldots \ldots \ldots

cially designed alternating current conductivity cell, based on the findings of Jones and Bollinger (8). In Fig. 5, a fair degree of correspondence is to be noted between experimental results and the simplified formulation of equation (8). The chief point of discrepancy appears to relate to location on the time axis. However, the results show clearly the marked effect of baffles, which is the salient point of the analysis.

Effect of Air Supply. Most of the previously described tests were conducted with agitation sufficient to keep activated sludge well stirred and suspended. It was proposed to investigate the effects of greatly increased air supply; that is, to increase the mixing constant, b^2. For a tank of ten

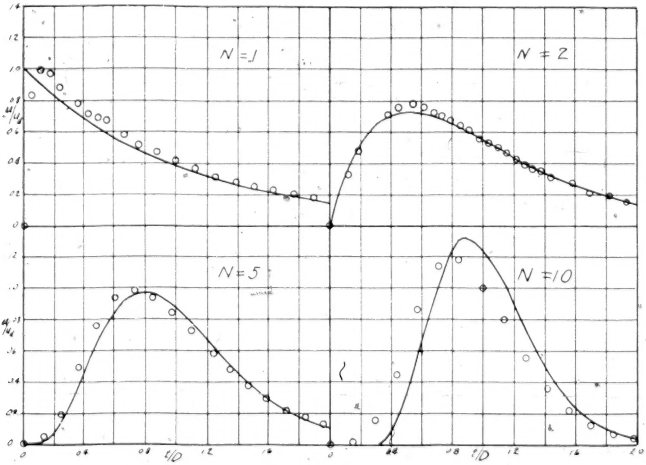

FIG. 5.—For perfect mixing and baffling, the flowing-through characteristics of an aeration tank may be represented by an equation. Theoretical curves and experimental results for $N = 1, 2, 5$, and 10 are presented to show that dispersion is decreased by the use of more baffles.

chambers, the results shown in Fig. 6 indicate that increased agitation causes the curve to be shifted so as to lead its normal position on the time axis. This effect, in accordance with the theory embodied in equation (2), shows that added turbulence favors short circuiting and causes a slower rate of die-away.

An investigation was also conducted to determine the effect of tapering the agitation. Since no attempt was made to gauge the air supply precisely, the curve in Fig. 6 does not represent any particular scheme of tapered aeration. However, the results do show a relative decrease in the short circuiting, probably as a consequence of lessened turbulence in the last few compartments which act as a buffer. On the other hand, the die-away is less rapid, indicating a greater effective dispersion.

Effect of Distributed Loading.—New activated sludge plants in New York City are designed to permit addition of sewage at several points along the aeration tanks. In order to investigate the effect, on the mixing

characteristics, of this incremental addition of sewage to mixed liquor; the flow into the experimental tank with ten compartments was made to simulate distributed loading with $Q/3$ entering the first chamber and $Q/6$ entering each of the next four compartments, Q being the total flow allowing for 20 per cent returned sludge. Into each of the first five compartments, salt solutions were introduced simultaneously in amounts proportional to flow, and the conductivity of the effluent determined. Results plotted in Fig. 7 are compared with theoretical curves from equation (8) for $N = 5$ and $N = 10$. The curve for distributed loading resembles those with decreased baffling, indicating a greater degree of short circuiting. This effect is to be expected since the salt placed in the fifth compartment had a much shorter path than the salt in the first com-

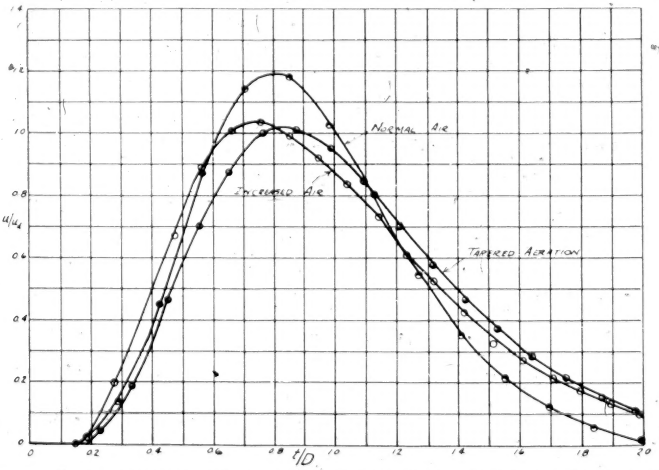

FIG. 6.—Effects of increased agitation and tapered aeration on the retention characteristics of a tank of ten chambers.

partment. It may be concluded, therefore, that multiple-point dosing operates to reduce the effect of baffling. Hence, with distributed loading, additional baffling appears to be necessary, particularly in the last half of the tank, to prevent discharge of undertreated sewage.

Passage of Pathogenic Bacteria.—As was mentioned previously, longitudinal mixing is an important factor in the survival of pathogenic organisms in the activated sludge process. The percentage removal of these pathogens depends largely on the rate at which the first portion of the sewage passes through the tank, for if this rate is rapid, the effluent may contain large numbers of viable organisms. The rate at which the remaining sewage passes out of the tank has little effect upon the overall bacterial efficiency, because after a short time, the number of pathogens is greatly reduced. Consequently, the mixing characteristics of a tank rather than the average detention period determine the survival of patho-

gens. Two tanks of equal detention may have greatly different bacterial efficiency as a result of differences in the degree of longitudinal mixing.

If sewage is added to a tank without baffles at points along the tank as in multiple-point dosing, the mixing and hence the bacterial survival may be changed considerably. Since this problem has practical significance, it is of interest to seek quantitative information from the theory of mixing.

The velocity of mixing is ordinarily so much larger than the displacement velocity that insofar as the first portion of the salt is concerned, it is possible to assume V in equation (1), to be zero. Then applying the boundary conditions that the concentration gradient at the ends be zero,

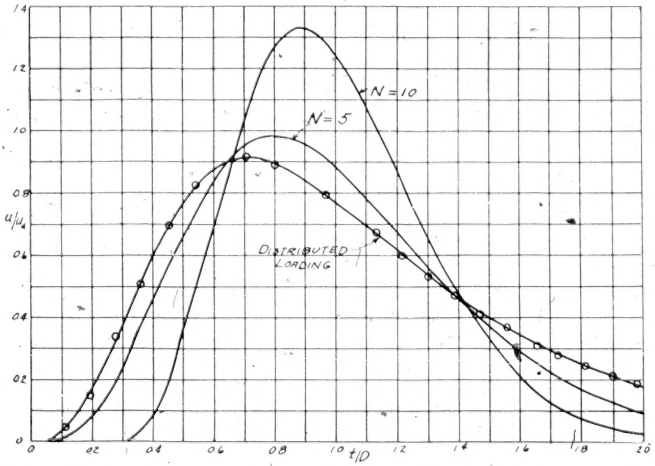

FIG. 7.—Relationship between distributed loading and longitudinal mixing. Distributed loading in the first five chambers of a ten-compartment tank operates to reduce the effect of baffling.

equations may be developed giving the concentration at the lower end when salt is introduced at different points along the tank. Curves of these equations are plotted in Fig. 8 for dosing at the upper end, one-quarter, one-half, and three-quarter points. The vertical scale is the relative concentration at the lower end; the horizontal scale is the dimensionless factor,

$$T = \frac{b^2\pi^2 l}{l^2}.$$

For a given tank and given degree of turbulence, this factor is proportional to time; hence, the curves indicate the relative rate at which the first portion of the salt reaches the lower end. The significant part of Fig. 8, therefore, is that portion to the left of say, $T = 1.0$.

A remarkable difference is noted in the time of passage depending upon the point of addition. For example, the salt introduced at the middle of

the tank travels the length in one-fourth the time required by salt that is introduced at the upper end. This disproportionality emphasizes again the necessity of baffles in tanks with multiple-point dosing.

The curves of Fig. 8 were derived for the condition of no flow and as such may be applied to aeration tanks in which the flow is intermittent. Since no salt is removed, the ultimate concentration is u_0, regardless of the point of dosage.

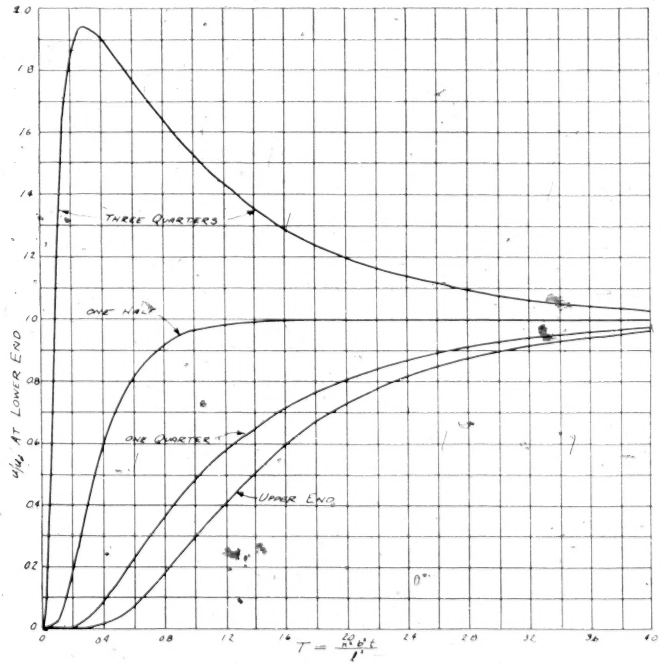

FIG. 8.—Relative rates at which the first portion of salt reaches the effluent end of a tank, for dosages at the upper end, one-quarter, half, and three-quarter points, for no displacement velocity in the tank.

Summary.—From this investigation, it is evident that the effects of the various factors influencing longitudinal mixing may be formulated in a rational manner. The factors studied include the degree of turbulence, the mean velocity of flow, the length of the tank, the number of baffles, and the degree of constriction at the baffles. A theory of mixing has been developed which may be applied toward a better understanding and control of the activated sludge process, particularly in relation to problems brought about by toxic wastes, pathogenic bacteria, and bulking of sludge. The need for baffles is indicated especially in designs employing tapered aeration or distributed loading.

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ANALYSIS OF SEWAGE IN ARMY CAMPS

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The operation of sewage treatment plants by the Corps of Engineers at many posts located in the various states comprising each Service Command requires technical advice and supervision on the part of the responsible Engineer officer and staff. This supervision can best be obtained by recurrent inspection of plant operation and through the interpretation of chemical, physical and biological analyses of each stage of the plant processes.

Special problems may arise at Army posts requiring detailed analyses of a complex nature. These include difficulties in biological treatment plants arising from industrial wastes in the sewage from certain posts having special missions. Other conditions arising from time to time may also influence the nature of the sewage to such an extent that the normal analyses will not indicate the character of the waste and its influence on the biological processes of the sewage treatment plant.

Not all of the sewage treatment plants in each Service Command are large enough to warrant the installation of a laboratory complete with necessary equipment for making all of the analyses required for control of operation. The larger plants are so equipped and employ a chemist or superintendent capable of making the required analyses.

The solution to the problem of sewage analyses at the smaller plants might possibly be the installation of a central laboratory to which samples could be shipped. Although this is practiced in the case of water analyses, sewage cannot be transported readily without changing some of its characteristics and therefore the analyses made at the central laboratory would not be representative of the conditions at the treatment plant. The other solution would be to establish a portable laboratory which could be transported to each post as desired. This latter solution has proved to be the most practical.

The portable laboratory purchased by the Army Engineers for use in sewage plant analyses was originally designed for water analyses by a soft-drink bottling firm. The laboratory was built in a trailer 6½ ft. wide by 15 ft. long. Extensive alterations were necessary in order to provide for the many types of equipment used in the analysis of sewage. A sedan was equipped with special springs and a strengthened clutch, as well as brake apparatus for operation of the trailer unit. The trailer and tractor are illustrated in Fig. 1.

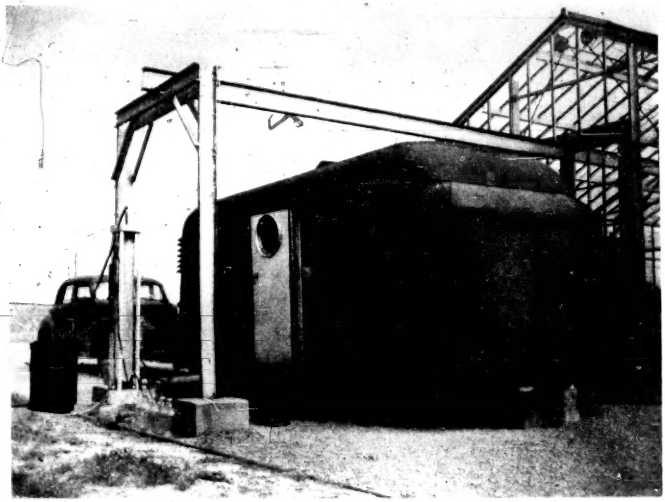

FIG. 1.—Trailer on location.

By means of the apparatus and equipment in the trailer laboratory it was possible to make the following analyses:

Biochemical Oxygen Demand	Ammonia Nitrogen
Oxygen Consumed	Organic Nitrogen
Relative Stability	Total Nitrogen
Dissolved Oxygen	pH
Suspended Solids	Alkalinity
Settleable Solids	Acidity
Total Solids	Hardness
Volatile Matter	Coliform Bacteria
Petroleum Ether Soluble Matter	Total Numbers of Bacteria
Nitrites	Microscopic Analyses
Nitrates	Gas Analysis

Experience showed that at one time or another, all of the above analyses had to be made, together with other special tests, in order to solve some of the unusual operating problems presented at Army camps.

The arrangement of the laboratory is illustrated in the floor plan shown in Fig. 2. This floor plan indicates the equipment both above and below the laboratory table which adjoins the walls of each side and the back inside the trailer. It will be noted how compactly all of the equipment was arranged in order to accomplish the required analyses within the limited space available.

Water supplies for the trailer were of several different types. Running water necessary for general laboratory operation was provided by

means of a hose connection from a fitting on the outside of the trailer to some convenient point in the sewage treatment plant where the trailer was stationed. This water was piped to the desired points inside the trailer. Satisfactory water supplies were always available at the plants visited. Special purpose waters were stored in tanks located under the roof of the trailer. These included distilled water produced by the laboratory still and B.O.D. dilution water.

Power for operation of the electrical devices in the laboratory was obtained by connecting to an outlet at each sewage plant. Vacuum pump, compressor, refrigerator unit, heaters, hot plates, and other equipment required a fairly heavy current which could best be supplied in this manner.

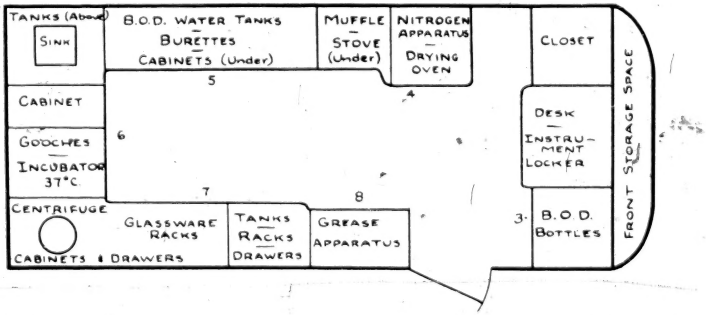

FIG. 2.—Floor plan of laboratory in 6½ ft. × 15 ft. trailer. Figure numbers of photographs noted on plan.

The conversion of an existing coat closet into a refrigerator and 20° C. incubator was accomplished as shown in Fig. 3. This closet was divided into several compartments in each of which a different temperature was provided. In the upper compartment was located the refrigeration machinery. In the middle compartment was located the freezing unit as will be noted in Fig. 3. This provided space in which samples could be stored as they were being collected and bacteriological media could be preserved. The lowest compartment was equipped with three trays each of which held twenty-four B.O.D. bottles. This compartment was provided with a refrigeration coil and a heater unit so that the temperature could be controlled within accurate limits by a sensitive thermostat. The separation of the B.O.D. bottles was made possible by means of wooden partitions. This permitted the trailer to be moved immediately after the last samples had been set up for B.O.D. determinations. It was found that the insulation was adequate so that the temperature would not change appreciably during the time of transit to the next post. Thus, the trailer would not have to remain at the preceding post for five days until the B.O.D. bottles could be incubated and the contents analyzed for dissolved oxygen. Successful operation was obtained with this arrangement.

Library and desk space was also provided in the trailer. A portion of this may be seen at the left side of Fig. 3. This space proved very useful in keeping data and reference material for the chemist.

Nitrogen determinations were made by means of the apparatus shown in the upper part of Fig. 4. Digestion was brought about in

FIG. 3.—Refrigerator and B.O.D. incubator.

flasks heated by means of the electrical unit shown in this photograph. Fumes were discharged into the exhaust manifold above the flasks and then vented to the atmosphere. Distillation was accomplished in flasks heated in a twin-unit electrical heater. Water supply for the condensers was furnished by the water line supplied from the sewage plant.

At the lower part of Fig. 4 is shown a portion of the drying oven used for the drying of samples in the analyses for suspended solids, total solids and other tests. A muffle furnace for oxidation of organic

material in determination of volatile matter is shown in the left hand side of this photograph.

Automatic burettes for the various titrations necessary in sewage analyses are shown in Fig. 5. These burettes were originally intended for analyses of water. However, the original solutions were replaced with the standard solutions required for alkalinity, acidity, dissolved

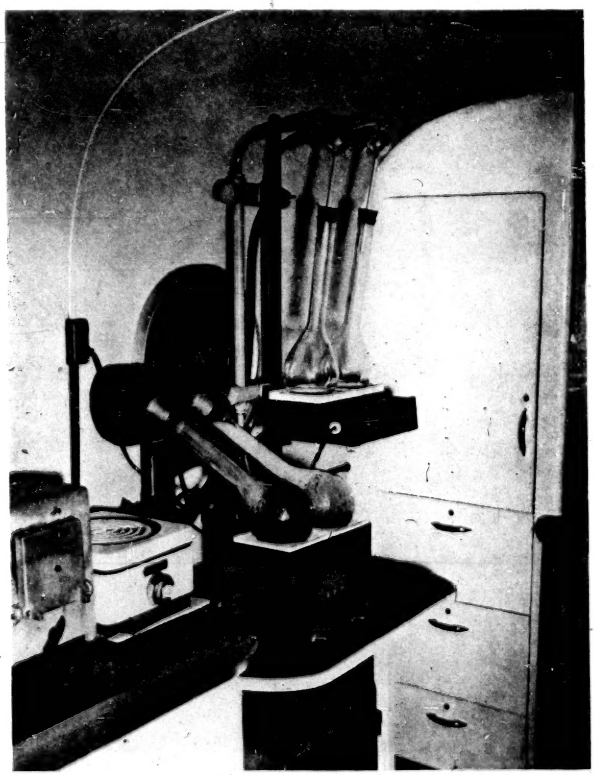

FIG. 4—Kjeldahl digestion and distillation equipment.

oxygen and other titrations. The compactness of these burettes made for excellent portability without breakage as the trailer moved from post to post.

The section adjoining the rear of the trailer is shown in Fig. 6. This was utilized for suspended solids determinations and bacteriological analyses. On the laboratory table behind the sample bottles may be noted a wooden rack with flasks and stoppers to hold Gooch crucibles.

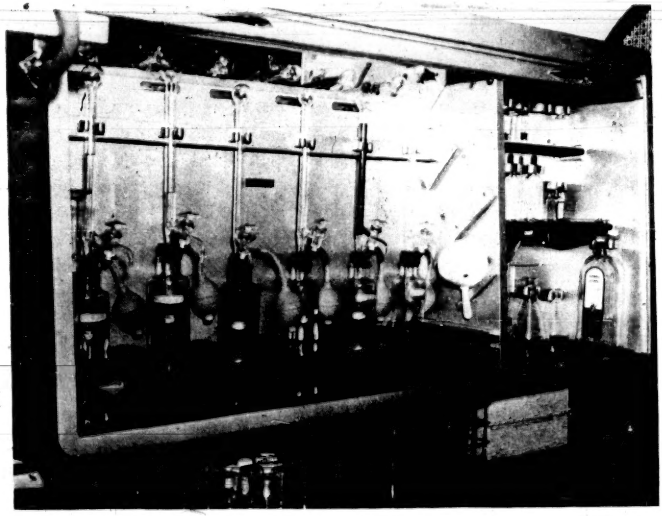

FIG. 5.—Burettes.

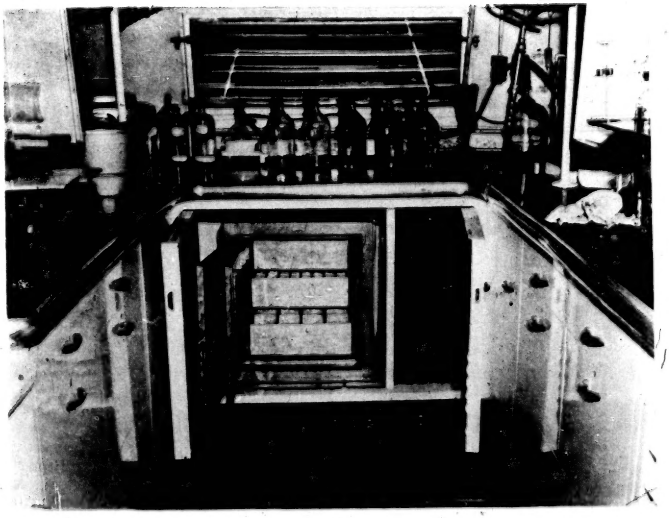

FIG. 6.—37° C. incubator and Gooch crucible apparatus.

These flasks served six Gooch crucibles at one time. Vacuum for the flasks was provided by means of an aspirator activated by water discharged through a pipe into the sink set in the table at the right hand portion of Fig. 6. This water supply also came from the sewage plant at which the trailer was stationed. Below the table was located a 37° C. incubator for bacteriological analyses. Wooden trays were provided to hold the necessary tubes for lactose broth or special Petri dishes.

The storage of beakers and other essential glassware, particularly during transit, proved to be a problem. This was solved by the installation of racks with wooden spacers as will be noted in Fig. 7. Not all of the glassware could be transported in this manner and the remaining

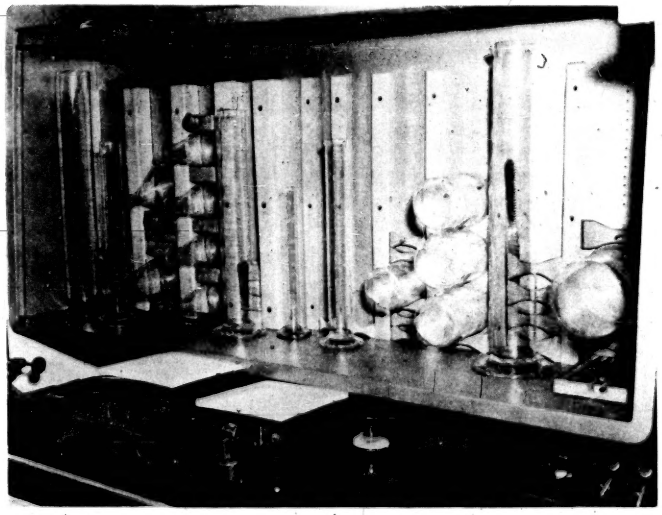

FIG. 7.—Glassware racks showing partitions used when travelling.

glass was packed separately, but was not available for ready use. These racks proved to be most useful.

Grease determinations are essential in the operation of many Army sewage treatment plants, particularly those involving biological processes. These analyses were made by means of the Bailey-Walker apparatus. A long hot plate was installed over which was mounted a battery of seven flasks in which Gooch crucibles could be placed. These crucibles contained the samples to be analyzed in accordance with a method developed by the authors. The complete apparatus including condenser, tubes and hot plates was mounted in a hood as shown in Fig. 8. Any fumes from the operation were discharged into the atmos-

phere outside the trailer. Grease determinations could be made rapidly and easily by means of this apparatus.

Certain items of equipment have not been illustrated in the figures noted above. These items include the sensitive balance constructed in such a manner that it could be taken apart and packed for transit without injury to the vital parts. A microscope was available for micro-

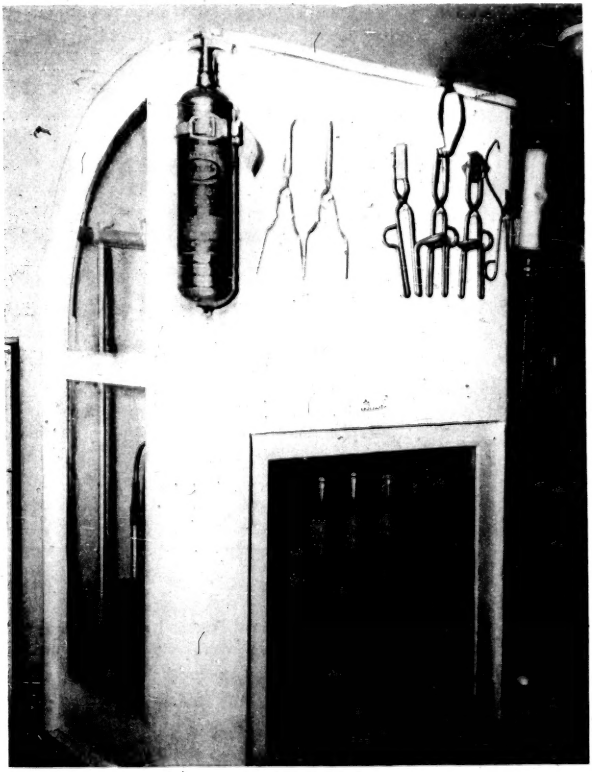

FIG. 8.—Hood and Bailey-Walker grease extraction apparatus.

scopic examinations of all types. A pH electrometer was provided for the determination of pH and for use in electrometric titrations. Many other items of laboratory significance were also included in the trailer.

The operation of this laboratory was conducted by a graduate chemist experienced in the field of sanitary chemistry. Helpers were provided where necessary for sample collection at the various sewage treatment plants. Routine analyses were made of the operation of many

sewage treatment plants not equipped with laboratories. Special analyses were made of certain industrial wastes prevalent at a number of the specialized posts, particularly those engaged in the manufacture or development of certain types of equipment involving the use of liquids in some of their processes and subsequently discharging liquid wastes. The availability of the laboratory to make these special analyses proved to be of great value in a number of instances.

The trailer laboratory has performed its functions in a creditable manner and has been worth the original investment many times over in its applicability to analyses of all types and its portability to bring specialized equipment to any post at any time.

Sewage Works Design

HIGH RATE TRICKLING FILTERS—THEIR DESIGN AND OPERATION*

By Samuel M. Ellsworth

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This introduction to the New England Sewage Works Association symposium on high rate trickling filters includes (*a*) a brief discussion of trickling filters of the early, conventional type, (*b*) a description of the general features of design and operation of high rate filters, (*c*) an account of the design and operation of a high rate trickling filter plant for an army cantonment, and (*d*) a discussion of construction costs and the place of high rate filters in the field of sewage treatment.

Trickling Filters of the Early, Conventional Type

Trickling filters have been employed successfully for sewage treatment for more than 40 years in this country and abroad. The conventional trickling filter plant usually includes preliminary sedimentation, either with separate collection and digestion of sludge, or combined collection and digestion in an Imhoff tank; the trickling filter itself consisting of a bed of coarse stone or slag 5 to 10 ft. deep over which settled sewage is distributed intermittently by means of fixed nozzles or moveable sprays; and final settling tanks (humus tanks) for the collection of settleable solids produced by the trickling filter.

Rates of application of sewage to conventional trickling filters have been expressed in various units such as m.g.a.d. (mil. gal. per acre daily), gal. per unit volume of filter stone, population per unit volume or B.O.D. load per unit volume. Conventional design rates of some of the older plants have ranged from 2 to 3 m.g.a.d., 300,000 to 400,000 g.d. per acre ft., or 2,000 to 4,000 persons per acre ft.

The old-type, conventional, trickling filter plant has given good service, has little mechanical equipment to maintain, has the ability to withstand the shocks of changing loads such as those imposed by industrial wastes, and will operate with a minimum of expert supervision. On the other hand the construction cost of such plants is relatively high, as is the hydraulic head required for their operation. Moreover, a trickling filter will clog when habitually overloaded and filter flies are decidedly objectionable in some locations at certain seasons of the year.

High Rate Filters

The distinguishing feature of a high rate trickling filter is the return and recirculation of filter or final tank effluent to the filter, thereby in-

*Presented at the Boston meeting of the New England Sewage Works Association on Sept. 22, 1943.

creasing the period of contact between the sewage and the filter medium. In general the same treatment elements are employed as those of a conventional trickling filter plant. With recirculation of filter effluent so that it passes through the filter two or more times, the volume of filter medium required for a given degree of treatment is much less than that required for the low rate, conventional filter. However, because of the higher rates of flow through portions of the treatment plant, the settling tank capacity, either preliminary, final or both, depending upon the flow diagram of the plant, must be larger than with the older type of plant. Also, substantial low-lift pumping capacity is required for the recirculation of the sewage.

Up to the present time two general types of high rate filters have been used, one usually known as the "bio-filter" initially developed by Jenks, and the other, known as the aero-filter, developed by Halverson and Smith. Both types are covered by patents.

The so-called bio-filter has been used extensively, particularly since the war. It is characterized by its relatively shallow depth and is employed for both single- and two-stage operation, the second stage being in series with the first, which is sometimes referred to as a roughing filter. Several flow diagrams for the recirculation of the sewage are in use in both single- and two-stage plants. Bio-filters can handle sewage loads per unit volume of filter as high as 5 to more than 10 times the corresponding loads placed on a conventional filter. On a population basis, the loading varies from about 15,000 to 40,000 persons per acre ft.

The aero-filter is not as common as the bio-filter. With this type of high rate filter, pumping of return sewage is varied so as to maintain a constant rate of flow through the filter. The depth of filter stone is generally greater than with the bio-filter and forced ventilation of the filter bed is employed to supplement thermal aeration.

Advantages Claimed for High Rate Filters

Perhaps the greatest advantage of the high rate filter is its ability to meet a wide range of conditions both as to the composition of the sewage to be treated and the requirements of the receiving waters. It appears to furnish that long-sought-for intermediate step between plain sedimentation and so-called complete treatment. Although first considered in this light, plants employing high rate filters have actually obtained results comparable to those given by conventional trickling filters.

With the continuous unloading of the filter the consequences of overloading are not as serious as those experienced with conventional filters where clogging of the filter and surface "pooling" is not uncommon. An excessive load on a high rate filter may lower its efficiency, but the filter responds quickly to a return to normal loading.

The continuous soaking of the filter stone virtually eliminates the filter fly which is so common about plants employing conventional filters with intermittent applications of sewage. Although flies may be present, most reports indicate that they are too few to be objectionable.

The construction cost of a high rate plant will generally be less than that of a conventional rate plant giving a comparable degree of treatment. However, the overall economy under these conditions remains to be demonstrated with actual operating records. It is probable that the greatest economy will result where the required degree of treatment is less than that given by plants giving "complete treatment."

Design and Operation of a High Rate Trickling Filter Plant

In 1940–41 a plant of this type was constructed for an army cantonment, referred to here as Post 7, which was laid out to accommodate about 30,000 troops. The use of high rate trickling filters was dictated mainly by hydraulic and site area limitations. Also, certain main sewers and a small sewage treatment plant to accommodate National Guard troops had already been constructed at this camp, making it desirable that the new works utilize as many of these facilities as possible.

Table 1.—*Basic Design Data and Comparison With Observed Flows*

Sewage Treatment Plant—Post No. 7

	Basis of Design	Operating Results
Population to be served	30,000	30,000*
Sewage Flows		
Raw sewage flow, average—m.g.d.	3.0	1.5
Raw sewage flow, maximum—m.g.d.	6.0	3.0
Average gross flow including raw and recirculated sewage—m.g.d.	7.5	5.5
(Note: Sufficient freeboard has been provided in the units so that a surge of 12.0 m.g.d. can be handled without overflowing the units.)		
Grease Skimming Flocculation Tank		
Length of tank—ft.	32.5	
Water depth—ft.	10.0	
Detention period for gross average flow including return sewage—min.	5.5	7.5
Capacity of pressure blower against 5 lb. pressure, cu. ft. of free air per minute	155	
Volume of air per gal. of gross average sewage flow, cu. ft. per gal.	0.03	
Air pressure—lbs.	4.5 to 5	
Number of 12-in. sq. diffuser plates	96	
Imhoff Tanks		
Number of tanks	2	
Length of tanks—ft.	90	
Width of each tank—ft.	50	
Depth from flow line to bottom of sludge hoppers—ft.	34	
Capacity for sedimentation—cu. ft.	74,300	
Overflow rate with gross average flow—gals. per sq. ft. per day	960	700
Detention period for gross average flow including return sewage—hrs.	1.8	2.5
Capacity for digestion—cu. ft. per cap.†	4.6	4.6
Sludge Storage Tanks (Converted from original settling tanks)		
Number of tanks	2	
Capacity for sludge storage—cu. ft. per cap.	1.0	1.0

* Converted to a population of 30,000 although population has reached 43,000.

† Capacity including sludge storage tanks 5.6 cu. ft. per capita.

TABLE 1—(*Continued*)

	Basis of Design	Operating Results
Trickling Filters		
Number of filters	2	
Diameter of each—ft.	100	
Depth of filter stone—ft.	3	
Total surface area—acres	0.36	
Rate of application of sewage with gross flow—m.g.a.d.	20.8	15.3
Rate of application of sewage with net flow—m.g.a.d.	8.3	4.2
Raw sewage B.O.D. loading—lbs. per cu. yd. stone	3.4	3.
Raw sewage B.O.D. loading—lbs. per acre ft.	5,550	4,950
Final Settling Tanks		
Number	2	
Diameter each—ft.	74	
Side water depth—ft.	8	
Water depth at center—ft.	11	
Detention period with gross average flow—hrs.	1.6	2.2
Overflow rate with gross average flow, gals. per sq. ft. per day	870	640
Overflow rate—gal. per sq. ft. per day	700*	530*
Sand Filters		
Total area including 4 acres of existing filters—acres	12	
Area of each bed—acres	0.5	
Underdrains	none	
Application of sewage—manually, by sluice gates		
Rate of application with average sewage flow—g.a.d.	250,000	125,000
Recirculation Pumps		
Recirculation ratio	1.5	2.7+
Gross rate of flow—m.g.d.	7.5	5.5
Number of recirculation pumps	3	
Capacities of pumps—g.p.m.	1 @ 1,000	
	1 @ 2,000	
	1 @ 3,000	
Sludge Drying Beds		
Number of beds	22	
Total area—sq. ft.	92,000	
sq. ft. per capita	3.0	3.0

* Assuming 1.5 m.g.d. taken from bottom of final tanks by recirculating pumps.

Briefly, the treatment units include a sewage comminutor, a control-section meter, a grease-skimming tank with diffused-air aerators, Imhoff tanks, two high-rate trickling filters with rotary distributors, three return sewage pumps, two circular final settling tanks with sludge collectors, 12 acres of intermittent sand filters and about 2 acres of sludge drying beds. In addition, two existing settling tanks were converted into sludge storage tanks. The size of units, the basic design data, and a comparison of the latter based on actual operating records are shown in Table 1, while a diagrammatic profile of the plant is shown on Fig. 1.

The treatment requirements at Post No. 7 are somewhat unusual. The purpose of treatment is to prepare the sewage for percolation into the ground, there being no open water course into which sewage can be discharged. The outfall sewer to the plant having been in existence when the camp was taken over by the Government, the area below this sewer which could be reached by gravity for percolation of sewage through sand filters was limited to about 12 acres. The allowable hy-

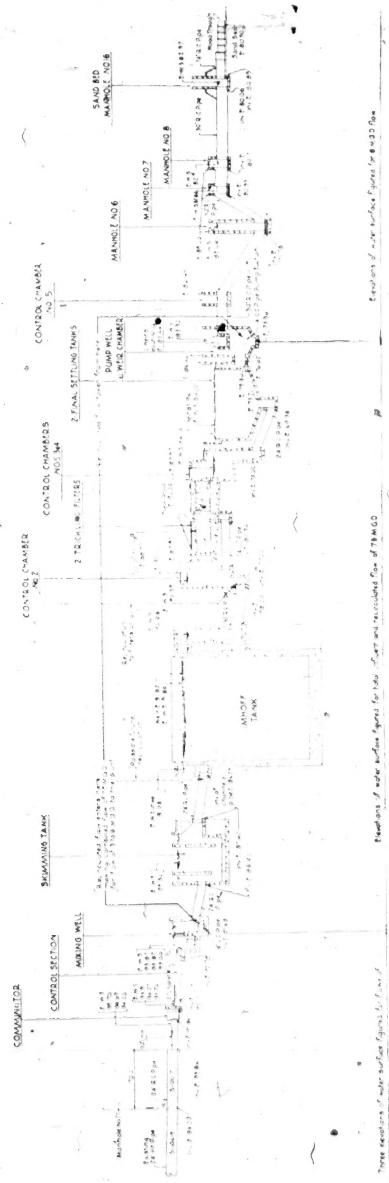

FIG. 1.—Diagrammatic profile through sewage treatment plant at Army Post 7.

draulic head for intermediate treatment units was also limited, and it was partly for this reason that shallow, high rate biofilters were used, this being the first such installation in this region, and about the only such large-scale installation used in conjunction with Imhoff tanks.

Time limitations, both for the planning and construction of the works, had a major influence on the final design. The original requirements of the War Department allowed only three months for the design and construction of the works. It was chiefly because of this requirement that Imhoff tanks were employed since their construction could be carried on to completion without risking delays in obtaining mechanical equipment.

Operating Results

The treatment works were put into partial operation in January, 1941 and in complete operation, with 6 acres of sand filters in service, toward the end of February. From the beginning the plant has had the benefit of laboratory supervision and, except for the first month of operation, operating statistics and analytical data have been generally adequate to furnish a reliable measure of the efficiency of the plant over a wide range of loadings.

Tables 2 and 3 give a summary of essential operating data based on monthly operating reports from July, 1941 to August, 1943, inclusive.

It should be noted that the final effluent referred to in the tables is the effluent from the final settling tanks as discharged onto the sand filters. As previously indicated the latter filters were provided only as a means of disposal of sewage into the ground. They are not underdrained and no record of their effect on purification is available or, in fact, needed.

The operating results shown by Tables 2 and 3, as well as Table 1, demonstrate among other things:

1. That the plant has served, to date, a maximum population of 43,000.
2. That in the early months of operation sewage flows were in excess of 100 g.c.d., but by various water conservation measures and an increasing population, the flows have dropped to less than 50 g.c.d.
3. That the suspended solids and B.O.D. of the untreated sewage, both measures of the population load, have increased in concentration as the per capita flows have decreased.
4. That the suspended solids content of raw sewage has been about 0.125 lb. per cap. per day, which is lower than originally expected.
5. That the B.O.D. content of the raw sewage has been close to 0.175 lb. per cap. per day, the amount assumed in the original basis of design.
6. That from a hydraulic and volumetric standpoint the works with the most recent per capita flows can handle the sewage from a population of about 60,000.
7. That from the standpoint of population the works can handle a load in excess of the design capacity, the evidence being that a population of over 40,000 persons can be served satisfactorily.

TABLE 2.—*Summary of Suspended Solids Loading*
Sewage Treatment Plant—Post No. 7

Month	Population	Sewage Flow		Suspended Solids Raw Sewage			Suspended Solids Final Effluent		Suspended Solids Removal	
		m.g.d.	g.c.d.	p.p.m.	lb./day	lb./cap./day	p.p.m.	lb./day	lb./day	%
1941										
July	25,692	2.371	92.3	138	2,730	0.106	46	910	1,820	66.7
Aug.	15,592	1.881	121.	116	1,820	.117	38	595	1,225	67.3
Sept.	14,190	1,604	111.	108	1,450	.102	37	495	955	65.8
Oct.	4,426	0.563	127.	130	620	.140	29	136	484	78.0
Nov.	4,522	0.361	80.0	152	458	.101	48	145	313	68.3
Dec.	14,700	1.090	74.0	189	1,710	.116	94	856	854	49.9
1942										
Jan.	19,970	1.189	59.5	221	2,190	.110	84	831	1,359	62.1
Feb.	18,113	1.109	61.2	234	2,160	.119	97	895	1,265	58.6
Mar.	18,500	1.048	56.7	248	2,170	.117	73	639	1,531	70.6
Apr.	19,100	1.057	55.3	268	2,360	.124	69	606	1,754	74.4
May	17,900	0.893	49.8	306	2,280	.127	65	483	1,797	78.8
June	18,452	0.930	50.3	279	2,160	.117	32	248	1,912	88.5
July	16,625	0.926	55.7	237	1,830	.110	25	193	1,637	89.4
Aug.	27,000	1.053	39.0	254	2,240	.083	31	273	1,967	87.8
Sept.	43,149*	1.192		281	2,800		50	496	2,304	82.3
Oct.	43,114*	1.220		273	2,780		63	641	2,139	77.0
Nov.	35,900	1.374	38.3	259	2,970	.083	79	906	2,064	69.5
Dec.	35,429	1.326	37.1	290	3,200	.091	82	905	2,295	71.8
1943										
Jan.	39,787	1.566	39.4	314	4,100	.103	105	1,370	2,730	66.6
Feb.	43,100	1.761	41.0	310	5,000	.116	103	1,514	3,486	69.7
Mar.	40,926	1.646	40.3	312	4,290	.105	101	1,390	2,900	67.6
Apr.	36,653	1.366	37.3	355	4,050	.110	70	798	3,252	80.3
May	38,000	1.282	32.4	400	4,110	.108	74	761	3,349	81.5
June	39,813	1.576	39.6	415	5,460	.137	57	750	4,710	86.3
July	40,000±	1.654		327	4,510	.113	42	580	3,930	87.1
Aug.	40,000±	1.715		333	4,770	.119	45	644	4,126	86.5

* Includes divisional troops in tents not connected to sewers.

In considering plant efficiency, various factors must be borne in mind. First, it is virtually impossible to appraise the efficiencies of the individual treatment units because of the varying rates of recirculation of sewage. Thus, when sewage is being returned to the Imhoff tanks it is greatly diluted and unless the rate of flow through the tanks is known and can be integrated for a 24-hour day, it is virtually impossible to compute the removal of suspended solids and B.O.D. in this stage of treatment. It therefore becomes necessary to consider overall plant efficiency, based upon the composition of the raw sewage and the final effluent, respectively.

As with any plant employing biological treatment, the efficiency generally varies directly with the temperature, biological action being substantially higher during the summer than during the winter months.

TABLE 3.—*Summary of B.O.D. Loading*
Sewage Treatment Plant—Post No. 7

Month	Population	Sewage Flow		Raw Sewage B.O.D.			Final Effluent B.O.D.		Removal B.O.D.	
		m.g.d.	g.c.d.	p.p.m.	lb./day	lb./cap./day	p.p.m.	lb./day	lb./day	%
1941										
July	25,692	2.371	92.3	249	4,940	0.192	108	2,130	2,810	56.9
Aug.	15,592	1.881	121.	225	3,550	0.228	70	1,100	2,450	69.0
Sept.	14,190	1.604	114.	187	2,500	.176	54	720	1,780	71.2
Oct.	4,426	0.563	127.	218	1,010	.228	31	146	864	85.5
Nov.	4,522	0.361	80.0	256	775	.171	47	141	634	81.9
Dec.	14,700	1.090	74.0	317	2,900	.197	107	970	1,930	66.6
1942										
Jan.	19,970	1.189	59.5	400	4,000	.200	118	1,170	2,830	70.8
Feb.	18,113	1.109	61.2	394	3,650	.202	111	1,020	2,630	72.1
Mar.	18,500	1.048	56.7	395	3,460	.187	84	730	2,730	79.0
Apr.	19,100	1.057	55.3	441	3,890	.204	77	680	3,210	82.5
May	17,900	0.893	49.8	445	3,300	.184	45	330	2,970	90.0
June	18,452	0.930	50.3	405	3,150	.171	33	260	2,890	91.8
July	16,625	0.926	55.7	380	2,930	.176	35	270	2,660	90.8
Aug.	27,000	1.053	39.0	402	3,500	.130	49	430	3,070	87.7
Sept.	43,149*	1.192	—	428	4,260	—	56	560	3,700	86.9
Oct.	43,114*	1.220	—	460	4,690	—	70	710	3,980	84.9
Nov.	35,900	1.374	38.3	490	5,620	.157	111	1,270	4,350	77.4
Dec.	35,429	1.326	37.4	420	4,650	.131	97	1,070	3,580	77.0
1943										
Jan.	39,787	1.566	39.4	556	7,250	.183	138	1,780	5,470	75.4
Feb.	43,100	1.761	44.0	540	7,930	.184	133	1,990	5,940	74.8
Mar.	40,926	1.646	40.2	590	8,100	0.198	108	1,480	6,620	81.7
Apr.	36,653	1.366	37.3	617	7,030	0.192	91	1,040	5,990	85.2
May	38,000	1.232	32.4	665	6,840	0.180	58	596	6,244	91.2
June	39,813	1.576	39.6	705	9,270	0.233	69	907	8,363	90.2
July	40,000±	1.654	—	660	9,110	0.228	70	966	8,144	89.4
Aug.	40,000±	1.715	—	567	8,110	0.203	66	945	7,165	88.3

* Includes divisional troops in tents not connected to sewers.

Monthly summaries of operating results must therefore be considered accordingly.

At Post No. 7 the efficiency of the plant has been affected materially by the number and experience of the operating personnel. During the past 2½ years changes in operating personnel have been frequent and there have been many occasions when essential maintenance work had to be postponed because of a shortage of personnel, thereby lowering the plant efficiency.

It will be seen from Tables 2 and 3 that in general the removal of suspended solids has varied from about 70 per cent to a little over 90 per cent, based on monthly operating records. On the same basis removals of B.O.D. have ranged from 75 per cent to a little over 90 per cent.

Prior to April, 1943, except for a few weeks in 1941, clarified sewage and settled solids from the final tanks were returned together to the mixing chamber ahead of the grease-skimming tanks, the rate of return being adjusted to maintain a comparatively uniform flow of sewage through the plant. Since April, final tank effluent has been returned directly to the trickling filters, while the settled solids from the final tanks have been pumped back separately and intermittently for final removal in the Imhoff tanks. This method of operation appears to give better results than the previous method, although it should be said that more efficient operation and maintenance of the plant during the past summer has probably contributed to the improvement in operating results.

An indication of the overall efficiency in terms of B.O.D. removal and B.O.D. load in lb. per day per cu. yd. of filter stone is shown in Fig. 2. This figure shows summer and winter trends based on monthly

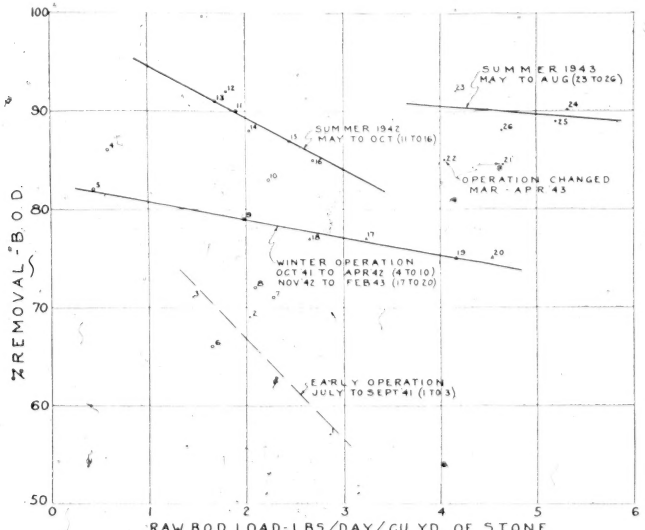

Fig. 2.—B.O.D. removals vs. raw sewage B.O.D. load at Army Post 7.

summaries of operating results for a period of 25 months beginning July, 1941. It will be seen that during the past summer the B.O.D. load has varied from about 4.2 to 5.3 lb. per day per cu. yd. of stone.

It is seen from Table 1 that a recirculation ratio of 1.5 was used in the basis of design. With the high sewage flow during the first months of operation this ratio was generally maintained. As the per capita sewage flows diminished, following water conservation measures, the recirculation ratio has increased so that for the past year it has

generally ranged from about 3 to 5. The three recirculating pumps of 1,000, 2,000 and 3,000 g.p.m. capacity, respectively, were designed for automatic operation by means of a float switch actuated by the water level at the control-section meter. As sewage flows increased, the rate of returning sewage was reduced by shutting off an operating pump and starting the next smaller unit. At present, with daily variations in sewage flows following a more or less uniform pattern, the return pumps are manually controlled, changes from one pump to another being made at appointed times during the 24 hours of the day.

Enlargements to Plant

During the past summer in anticipation of a substantial increase in the number of troops at this post the plant has been enlarged. A separate sludge digestion tank of 35,000 cu. ft. capacity has been added which is intended to be used in conjunction with the Imhoff tanks, receiving from them partially digested sludge for completion of digestion. The new tank is provided with heating facilities. About 15,000 sq. ft. of new sludge drying beds have been provided, as well as an additional 5 acres of sand filters. With these additions it is expected that the plant will provide for a population of double that anticipated in the original design.

Comparative Costs of Conventional and High Rate Filter Plants

Comparisons of construction costs at the present time must be based upon war conditions and may be of doubtful value. So far most of the high rate plants have been built for Army or Navy establishments where construction has been carried on under various contract procedures.

For what they may be worth the following figures are presented:

Camp	Design Population	Per Capita Cost of Plant
Low Rate Trickling Filters		
A	40,000	$11.00
B	35,000	14.30
C	35,000	12.10
D	35,000	10.10
Average		11.87
High Rate Trickling Filters		
C	35,000	$11.80
D	22,500	10.60
E	35,000	9.20
F	20,000	10.40
Average		10.50

From this comparison the average conventional type plant costs about 13 per cent more than the high rate plant, but the cost data are so limited and conditions of design and construction so unusual that the comparison is of uncertain value.

The Future of High Rate Filters

Much will be learned about this method of sewage treatment from the data coming from the military establishments in this country. Already there is evidence that design factors have been over-conservative. As more results of operation become available greater refinements in design will follow, with the result that plants can be designed for definite loads, using only normal safety factors, with reasonable assurance of their ability to handle such loads. Under such conditions real construction economy should be possible.

Thus far flow diagrams and operating procedures are in a state of change and development. Eventually the design and operation of such plants will take a more conventional form although the possibilities for further development and exploitation still appear to be great.

For industrial wastes and for sewage containing high concentrations of such wastes the high rate trickling filter appears to have great possibilities. The ability to adjust the rate of recirculation to the raw sewage load gives greater flexibility than is possible with a low rate trickling filter plant. In this respect the high rate filter is somewhat like an activated sludge plant, although much less sensitive to changing loads.

EXPERIENCE WITH HIGH RATE TRICKLING FILTERS AT ARMY POSTS IN NEW ENGLAND *

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AND

J. Raymond Snell

Sanitary Engineer, Water and Sewer Section, Repairs and Utilities Branch, First Service Command

For purposes of distinction, the three sewage treatment plants at Army Posts in the First Service Command using high rate trickling filters will be designated as Posts VII, A, and B. The filters have been in operation 33, 20 and 3 months respectively.

Experience with each of these high rate trickling filters has been for the most part satisfactory. They appear to be capable of withstanding considerable rough treatment and give high efficiencies even when more than 50 per cent overloaded.

The filters at each post show certain very interesting information when their B.O.D. loadings and efficiencies are plotted against time. Figure 1 gives a running picture of the monthly average pounds of B.O.D. in the raw and the settled sewage per acre foot of filter stone for the past 33 months at Post VII. Below this are plotted the corresponding monthly average efficiencies shown in two ways: (*a*) actual efficiency expressed as per cent of overall B.O.D. removal and (*b*) expected average efficiency, or what might be expected for the given loading on an average filter.

This expected average efficiency for each monthly loading is taken directly from a graph which shows a straight line ratio between B.O.D. loading and efficiency. This assumption of a straight line ratio was made from a study of data taken from several Army camps and appears in a paper presented in the November, 1942 Sewage Works Journal, by Kessler and Norgaard.

The bottom line of Fig. 1 is merely a replotting of the difference between the expected average efficiency and the actual efficiency. When the actual efficiency is higher than the expected average, the curve is expressed as a positive percentage, while if it is lower, it is expressed as a negative percentage.

The following observations are indicated by these curves:

1. The efficiency of the filter increased decidedly over a period of the first 3–4 months, and showed a gradual increase during the first year.
2. A definite relationship exists between B.O.D. load and efficiency.
3. The efficiency of the filter was higher in summer than in winter.

* Presented before New England Sewage Works Association, September 22, 1943.

4. If a correction factor is applied to offset the effect of the variation in temperature, the relationship between B.O.D. load and efficiency might approach a straight line relationship.

5. High efficiencies were obtained at loadings more than 50 per cent greater than those normally recommended.

Difficulties at this plant with sedimentation and sludge removal last winter affected the filters and are indicated in the efficiency curve. It can also be seen that the difficulties are apparently being overcome.

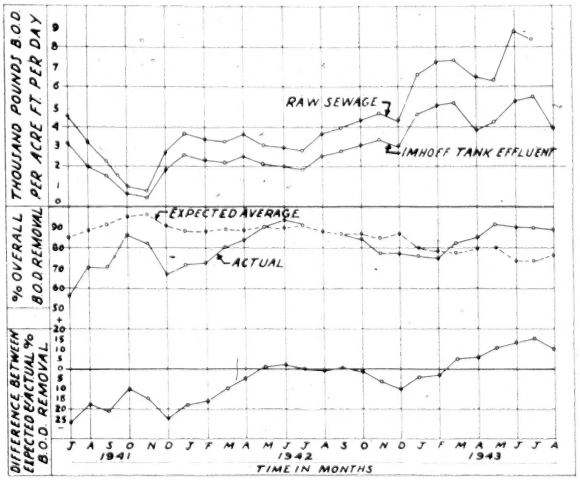
THOUSAND POUNDS BOD PER ACRE FT PER DAY
RAW SEWAGE
IMHOFF TANK EFFLUENT
% OVERALL BOD REMOVAL
EXPECTED AVERAGE
ACTUAL
DIFFERENCE BETWEEN EXPECTED & ACTUAL % BOD REMOVAL
J A S O N D J F M A M J J A S O N D J F M A M J J A
1941
1942
1943
TIME IN MONTHS

FIG. 1.—Efficiency of high rate trickling filter at Army Post VII. Filter placed in operation July 19, 1941.

A factor in the increased efficiency of these filters is a change in operation during the spring of 1943, whereby the major portion of the return overflow from the final tanks was diverted from ahead of the primary sedimentation to the filters directly, leaving only a relatively small quantity of underflow containing the secondary sludge, returned ahead of primary sedimentation. Still another factor was improved operation of the Imhoff tanks to prevent escape of rising sludge solids.

Post A has two 32-foot diameter, 6.1 ft. deep filters containing 0.224 acre feet of crushed stone and equipped with two-arm distributors. The filters are preceded by Imhoff tanks and followed by manually cleaned secondary clarification tanks. Recirculation is to a point ahead of the filters with secondary sludge returned periodically to the Imhoff tanks. The recirculation ratio varied from 1.22 to 5.35 and averaged 2.55. The rate of application of both raw and recirculated sewage varied from 17.8 to 9.7 and averaged 13.6 million gallons per acre per day.

The second filter of this plant was added in November 1942, along with a second Imhoff tank and secondary clarifier.

Post B has two 100-foot diameter, 3.0 ft. deep filters containing 1.08 acre feet of crushed stone. These filters have four-arm distributors. They are preceded by primary clarifiers and followed by secondary clarifiers with continuous sludge removal equipment in both.

Recirculation pumps take a portion of the secondary clarifier effluent and pump half ahead of the primary clarifier and half just ahead of the trickling filters. Secondary sludge is returned to the primary clarifiers with the recirculated sewage. The recirculation ratio was stepped up from about 2.0 for the first two months to 3.55 for the last month. This increased the rate of flow from about 4.0 million gallons per acre per day the first two months to 8.12 the last month.

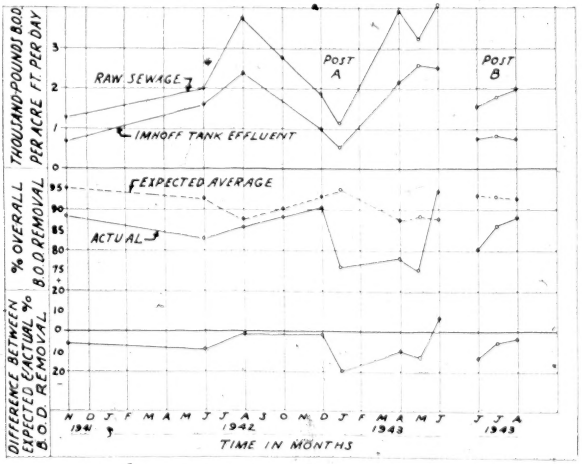
THOUSAND POUNDS B.O.D. PER ACRE FT. PER DAY
RAW SEWAGE
IMHOFF TANK EFFLUENT
POST A
POST B
% OVERALL B.O.D. REMOVAL
EXPECTED AVERAGE
ACTUAL
DIFFERENCE BETWEEN EXPECTED & ACTUAL % B.O.D. REMOVAL
N D J F M A M J J A S O N D J F M A M J J A S
1941
1942
1943
TIME IN MONTHS

Fig. 2.—Efficiency of high rate trickling filters at Army Posts A and B.

Figure 2 shows the same relationships for Posts A and B given in Fig. 1 for Post VII.

The same general observations can be demonstrated in this figure. However, because the data for Post A are not taken from monthly averages but from a few scattered one-day samples, they are less reliable.

The overall efficiency of both filters at Post A went down considerably for a period of 6 months after the No. 2 filter had been put in operation.

This slump in efficiency may be due in part to the fact that the operator attempted to operate the filters as two-stage, putting all the undiluted Imhoff tank effluent on one filter and all recirculated final effluent on the second filter. This resulted in an extremely heavy growth on

the first filter, almost to the point of clogging. A sharp increase in efficiency is noted following a change to the designed single stage method of operation.

It is interesting to note that Post B filters show a progressive increase in efficiency during the first three months of operation.

Filter flies have not been a serious problem at any of these plants. While a few reach the flying stage, most of them are washed out in the filter effluent and collect on the surface of the final tanks and in the sludge. At one of the plants, dead flies have accounted for practically all of the settleable solids in the final effluent.

HIGH RATE BIOLOGICAL SEWAGE TREATMENT—A DISCUSSION*

By Frank A. Marston

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Mr. Greeley has presented a comprehensive description and evaluation of high rate trickling filters and short-period aeration methods of sewage treatment. He rightly points out that records of operation of high rate biological treatment plants of different kinds are not sufficiently comparable to permit determination of very definite relationships. Differences in character and strength of sewage and in operating conditions affect the accomplishments. The type of plant to be recommended in each specific case will depend upon the characteristics of the sewage, the degree of treatment required, and other local factors.

Standard Rate Trickling Filter at Fitchburg, Massachusetts

One of the early trickling filters in this country was that at Fitchburg, Massachusetts. This plant includes Imhoff tanks, trickling filter, secondary sedimentation tanks, and sludge drying beds. It was put in operation October 14, 1914.

The trickling filter consists of an area of 2.12 acres of broken stone 1 to 2 inches in size and 10 ft. deep. The Imhoff tank effluent is sprayed upon the filter by alternating dosing tanks and fixed nozzles. The filter was designed to treat the sewage on the basis of 2,000 persons per acre-foot or 2 m.g.d. per acre.

The plant has given a good degree of efficiency. Except during the early years, the filter fly has not been troublesome. Small spiders became numerous in the upper part of the filter and an equilibrium was apparently established so that neither the spider nor the fly was objectionable.

During the period from November 30, 1918 to May 26, 1920, the working area of the filter was reduced to 1.24 acres, to correspond with a loading of 3,000 persons per acre-foot, equivalent to 3.69 m.g.d. per acre. There was no material increase in accumulation of organic growths on the surface of the filter or in pooling of the sewage. Although the effluent was not of quite so high quality as before the increase in loading, the efficiency of the plant was still high. B.O.D. determinations were not made at that time, but assuming the 5-day B.O.D. to be 0.17 lb. per capita per day, the B.O.D. loading amounted to a little over 500 lb. per day per acre-foot. The standard methylene blue relative stability test was made on 24-hour daily composite samples, and every sample throughout the year 1919 remained stable for the full test period of 14 days. The effluent contained an average of 7.27 p.p.m. of nitrate

* This paper is a discussion of the article "High Rate Biological Sewage Treatment" by Samuel A. Greeley, published in the November, 1943 issue of *This Journal*. It may also be considered a discussion of the article "High Rate Trickling Filters—Their Design and Operation," by S. M. Ellsworth, published in this issue.

nitrogen. It was obvious that the filter had not been loaded to its maximum capacity. The foregoing is illustrative of the loading that has been carried by a standard rate trickling filter.

Recirculation at Plainfield, New Jersey, Plant

All of the principal types of high rate trickling filters involve recirculation of the filter effluent, either before or after sedimentation, either to the primary sedimentation tank or to the trickling filter. Continuous dosing of the trickling filter has resulted in higher permissible rates of operation without clogging and has practically eliminated the filter fly nuisance experienced at many of the standard trickling filter plants.

John R. Downes, in an unpublished report, states that in 1927, during experiments at the joint sewage disposal plant of Plainfield, North Plainfield, and Dunellen, New Jersey, on recirculation of the trickling filter effluent to the influent for control of odors at the nozzles, a reduction in the number of filter flies was noticed, indicating that a continuous spray on the filter area might reduce the fly nuisance.

Practical application of this idea was started in the fall of 1936 with favorable results. The maximum capacity of the nozzle field at mean head in the dosing tank is established, and enough trickling filter effluent is pumped back to the dosing tanks to maintain this flow at all times. Butterfly valves on the outlets of the dosing tanks are operated by ¼-hp. motors on a 35-second cycle from zero to full head, thus constantly changing the umbrella-like conformation of the spray from zero head to the full spray at a head of 14 feet, so that every part of the bed area is continuously sprayed. Odors have been very materially reduced by recirculation and the fly nuisance has been practically eliminated.

The accomplishment of the plant with recirculation is indicated as follows:

Trickling filter, 1.78 acres 6 ft. deep = 10.68 acre feet = 17,230 cu. yd.
Total flow of sewage treated, 4.14 m.g.d.
Rate of flow to filter with recirculation, maintained at 7 m.g.d.:

Average B.O.D. in p.p.m.		B.O.D. Removal	
Raw sewage	570	By primary settling, 220 p.p.m.	= 38.6 per cent
Settled sewage	350	By trickling filter, 326 p.p.m.	= 93.1 per cent
Trickling filter effluent	24	By final settling, 9. p.p.m.	= 37.5 per cent
Final settling tank effluent	15	Overall B.O.D. removal, 555 p.p.m.	= 97.4 per cent

Average B.O.D. removal per acre-foot per day, 1,050 lb.
Average B.O.D. removal per cu. yd. per day, 0.65 lb.

Results of High Rate Trickling Filter Treatment of Sewage at Liberty, New York

This plant, designed by Colonel W. A. Hardenbergh, comprises primary and secondary sedimentation, two-stage "biofiltration" with recirculation of effluent and final treatment through a magnetite filter. The sewage in summer is strong and the summer population is more than double that in winter. The sewage contains dairy and laundry wastes so that the equivalent population in summer is of the order of 17,000.

Characteristic results of the treatment plant operation are indicated by the records for about two months during the summer of 1941. Primary filter effluent was recirculated to the primary sedimentation tank at a rate of 1,400 g.p.m., and effluent from the secondary settling tank was recirculated to the secondary filter at the same rate. Thus, the average rate of dosing each of the filters was 24.4 m.g.d. per acre, based on the average flow of raw sewage. The ratio of rate of recirculation of effluent to rate of flow of incoming sewage was about 2.5 to 1 for each of the two recirculation stages. Each of the filters is octagonal in plan, 80 ft. in diameter. The depth of crushed stone is 3 feet.

Results of Operation.—(Averages for period June 4 to Aug. 1, 1941.)

Sewage flow, average rate	795,000 gal. per 24 hours
Average detention period in primary sedimentation tank for raw sewage and recirculated filter effluent	1.2 hours
	5-day B.O.D.
Raw sewage	435 p.p.m.
Primary sedimentation tank effluent	184
Primary filter effluent	132
Secondary filter effluent	57
Secondary settling tank effluent	23
Loading in pounds per day, of applied B.O.D. per acre-foot of filters	1,770
Loading in pounds per day of B.O.D. in raw sewage per acre-foot of filters	4,175
Loading in pounds per day of B.O.D. in raw sewage per cubic yard of crushed stone	3.25
Reduction in B.O.D. excluding magnetite filter	94.7 per cent

Local conditions were such as to permit operation of the plant at reduced efficiency during the colder months and accordingly recirculation of the effluent was omitted. Therefore, comparable results from winter operation as a high rate trickling filter plant are not given. It should be noted that the average loading applied to the filters was only 1,770 lb. of B.O.D. per acre-foot per day as compared with a rate of 3,000 lb. "often applied to high rate filters." This may account in part for the high removal of B.O.D.

The records show that the filters at Liberty respond rapidly in the Spring with increased efficiency when recirculation of the effluent is started again after having been stopped for the winter. With the strong sewage treated at this plant the results are favorable to two-stage filtration as compared to the unfavorable results obtained at one of the Army Post plants referred to later.

High Rate Trickling Filters at Army Camps

The consulting engineers to the Engineering Branch of the Construction Division of the War Department, in their report dated December, 1940, recognized that although high rate trickling filters were still in the developmental stage, experience had demonstrated their ability to meet the requirements in certain cases under proper loadings. Consequently they were included in the approved means of sewage treatment to be considered for National Defense projects. I understand that in

most cases where high rate trickling filters for the army sewage treatment plants were properly constructed and properly operated under designed loads, they have satisfactorily performed their functions and in many cases have handled considerable overloads without trouble.

At a meeting of the New England Sewage Works Association in Boston on September 22, 1943, a paper entitled "The Operation and Design of High Rate Trickling Filters" was presented by Samuel M. Ellsworth, discussing one of these high rate trickling filter sewage treatment plants.

High Rate Trickling Filter Plant at Post No. 7

Mr. Ellsworth discussed the design and operation of a high rate trickling filter plant constructed in 1940–41 for an army cantonment referred to as Post No. 7, laid out to accommodate about 30,000 troops. The use of high rate trickling filters was dictated mainly by hydraulic and site area limitations. The function of the high rate trickling filters was to prepare the sewage for percolation into the ground, there being no open water course into which the effluent could be discharged.

The treatment plant units include a sewage comminutor, a control-section meter, a grease-skimming tank with diffused air aerators, Imhoff tanks, two high rate trickling filters with rotary distributors, three return sludge pumps, two circular final settling tanks with sludge collectors, 12 acres of intermittent sand filters, and about two acres of sludge drying beds. The basic design data and comparative operating data are given together with a diagrammatic profile of the plant. This plant was put in complete operation towards the end of February, 1941.

The principal operating data of the trickling filters based on the population of 30,000 were as follows:

Sewage flow	
Average m.g.d. (million gallons daily)	1.5
Maximum m.g.d.	3.0
Recirculation ratio	2.7 +
Average gross flow including recirculated effluent, m.g.d.	5.5
Imhoff tanks for preliminary treatment	
Detention period for average gross flow, hours	2.5
Overflow rate at average gross flow, gallons per square foot per day	700
Trickling filters	
Area, acres	0.36
Depth of filter stone, ft.	3.0
Volume of filter stone, cu. yd.	1,750.0
Rate of application based on sewage only, m.g.d.a. (million gallons per day per acre)	4.2
Rate of application at average gross flow, m.g.d.a.	15.3
Raw sewage B.O.D. loading	
lb. per acre-foot	4,950.
lb. per cu. ft. of stone	3.*
Final Settling Tanks	
Detention period at average gross flow, hr.	2.2
Overflow rate at average gross flow, gal. per sq. ft. per day	530.†

* During the past summer the B.O.D. load has varied from about 4.2 to 5.3 lb. per day per cu. yd. of filter stone.

† Assuming 1.5 m.g.d., taking from bottom of final settling tanks by recirculating pumps.

The monthly operating results given for July, 1941 to August, 1943 show in general an overall removal of suspended solids by the plant, not including the sand filters, 65 per cent to 90 per cent, the suspended solids in the effluent ranging from 25 to 105 p.p.m. On the same basis the overall removal of B.O.D. ranged from about 70 per cent to a little over 90 per cent, the B.O.D. of the effluent ranging from 31 to 138 p.p.m. It is stated that prior to April, 1943, except for a few weeks in 1941, effluent and settled solids from the final tanks were returned together to the mixing chamber ahead of the grease-skimming tanks, the rate of return being adjusted to maintain a comparatively uniform flow through the plant, but that since that time, the final tank effluent has been returned directly to the trickling filters, while the settled solids from the final tanks have been pumped back separately and intermittently for removal in the Imhoff tanks. It is stated that this method of operation appears to give better results than the previous method.

In a discussion of this paper Major G. E. Griffin presented curves of B.O.D. loadings and efficiencies plotted against time and expected average efficiency, showing that a definite relationship exists between B.O.D. load and efficiency, but that the efficiency is higher in summer than in winter and that high efficiencies were obtained at loadings more than 50 per cent greater than those normally recommended.

Major Griffin also presented information and data relating to the sewage treatment plant at, so-called, Army Post A.

High Rate Trickling Filter Plant at Post A

At Post A, there is a high rate trickling filter which is not in accordance with any of the patented types of high rate trickling filters. This plant was originally designed for 2,500 persons at 22,500 persons per acre-foot which is equivalent to an estimated 5-day B.O.D. Imhoff tank effluent loading of 2,930 lb. per acre-foot of filter. This plant was put in operation in November, 1941. Subsequently, it was doubled in size to serve 5,000 persons.

The plant includes Imhoff tanks designed for a detention period of 3⅓ hours at average sewage flow; two trickling filters 32 ft. in diameter and 6 ft. deep, containing 0.222 acre-foot of crushed stone, and provided with four-arm rotary distributors; and secondary settling tanks designed for a detention period of 1.5 to 2.0 hours at average sewage flow plus recirculated effluent, the sludge to be pumped periodically to the Imhoff tanks.

According to the design, secondary tank effluent is automatically pumped back to a point ahead of the trickling filters at a rate of about 9.7 m.g.d.a., when the rate of sewage flow falls below 13.5 m.g.d.a.; and the recirculation pump cuts out when the sewage flow reaches 24.4 m.g.d.a. The filter operating rates could accordingly vary from 9.7 to about 34 m.g.d.a., all continuous flow.

The sewage flow adopted for the design basis was 100 gal. per capita per day, but has actually been only about one-half that amount, so that

the rates of flow of sewage and recirculated secondary tank effluent have been much less than that designed for.

Operation of the enlarged plant began in November, 1942. The efficiency of the plant went down considerably for a period of nearly 6 months after the second trickling filter had been put in operation. This reduction in efficiency is believed to have been due to the fact that the operator attempted to run the trickling filters on a two-stage basis, putting all the undiluted Imhoff tank effluent on one filter, and recirculating the secondary tank effluent only to the second filter. This resulted in an extremely heavy growth on the first filter, almost to the point of clogging. A sharp increase in efficiency was noted following a change to the designed single-stage filter method of operation.

Through the courtesy of the Director of the Bureau of Sanitary Engineering of the local State Department of Health, results were obtained for analyses of composite samples of the raw sewage, Imhoff tank effluent, and final effluent made up of individual samples collected at 15-min. intervals generally between 8 A.M. and 4 P.M. The results for suspended solids and 5-day B.O.D. of three sets of samples collected during the summer of 1943 are reproduced in the following tabulation:

Results of State Department of Health Analyses of Composite Day Samples of Sewage, Imhoff Tank Effluent and Final Effluent from Sewage Treatment Plant at Post A, Summer of 1943

Date of Collection of Samples, 1943	Sample	Suspended Solids, p.p.m.	B.O.D., p.p.m.
May 26	Raw sewage	220.0	260.0
	Imhoff tank effluent	76.0	160.0
	Per cent reduction	65.0	38.5
	Final effluent	17.0	16.0
	Overall per cent reduction	92.3	93.8
July 18	Raw sewage	220.0	250.0
	Imhoff tank effluent	88.0	160.0
	Per cent reduction	60.0	36.0
	Final effluent	23.0	18.0
	Overall per cent reduction	89.5	92.8
Aug. 22	Raw sewage	170.0	220.0
	Imhoff tank effluent	74.0	150.0
	Per cent reduction	56.5	31.8
	Final effluent	18.0	15.0
	Overall per cent reduction	89.4	93.2
Average	Raw sewage	203.0	243.0
	Imhoff tank effluent	79.0	157.0
	Per cent reduction	61.1	35.4
	Final effluent	19.0	16.0
	Overall per cent reduction	90.6	93.4

The averages of the results for the three sets of samples show an overall reduction of 90.6 per cent in the suspended solids and 93.4 per cent in the B.O.D.

Through the courtesy of the chief of the Sanitary Engineering Section, Repairs and Utilities Branch of the Service Command of the area which includes Post A, there have been obtained operating data including those for May 26, July 18 and August 22, 1943, the days for which the analyses have been given. The B.O.D. loadings of the trickling filters have been computed from the results of analyses of the Imhoff tank effluent and the secondary tank effluent recirculated and the flows of each. These data are as follows:

Operating Data for Days for Which Results of Analyses are Given

	May 26, 1943	July 18, 1943	Aug. 22, 1943	Average
Sewage flow, m.g.	0.252	0.326	0.286	0.288
Secondary tank effluent recirculated, m.g.	0.180	0.157	0.165	0.167
Total flow of Imhoff tank effluent and recirculated secondary tank effluent, m.g.	0.432	0.483	0.451	0.455
Rate of application to trickling filters, m.g.d.a.	11.7	13.1	12.2	12.3
5-day B.O.D. loading, lb. per acre-foot per day Imhoff tank effluent	1,513	1,957	1,610	1,693
Secondary tank effluent recirculated	108	107	93	103
Total	1,621	2,064	1,703	1,796

The results for these three days cannot be considered applicable to the entire summer of 1943. However, they are indicative of the accomplishment. The flow data for these days are not greatly different from the corresponding average monthly data. The B.O.D. loadings shown are considerably lower than the design basis due presumably to a smaller population served at this time. These B.O.D. loadings of the trickling filters must not be confused with the raw sewage B.O.D. loading of the plant sometimes reported in terms of pounds per day per acre-foot of trickling filters, on which basis the loadings would average approximately 2,700 lb. per acre-foot per day. Filter flies have not been numerous enough to be objectionable.

Effect of Temperature on Removal of B.O.D. by Trickling Filters

Mr. Greeley's paper presents curves showing the relationship between removal of B.O.D. by filters and final tanks and the loading on the filters. High rate trickling filters, as with all biological activities, are influenced in their operation by temperature. This may be illustrated by operating data presented by Mr. Ellsworth and by Major Griffin, relating to the operation of the high rate trickling filters at Post No. 7, the sewage treatment works for which have previously been described. The operating data given below do not include the effect of the sand filters. The overall removals of B.O.D., grouped according to winter and summer periods, are as follows:

Period	Raw Sewage Loading, lb. per acre-ft. per day	Average Monthly Mean Air Temperature, ° F.	Overall Removal of B.O.D., per cent
Average of 5 winter months, Nov. 1941–Mar. 1942	2,735	36.1	74.1
Average of 5 summer months, May–Sept., 1942	3,174	64.5	89.4
Average of 5 winter months, Nov. 1942–Mar. 1943	6,210	33.2	77.3
Average of 4 summer months May–Aug. 1943	7,710	52.3	89.8

The removals of B.O.D. during the warmer periods were substantially higher than during the colder periods. The effect of lower temperatures in reducing the efficiency of the process may be illustrated also by Fig. 1, which shows the relationship between removal of B.O.D.

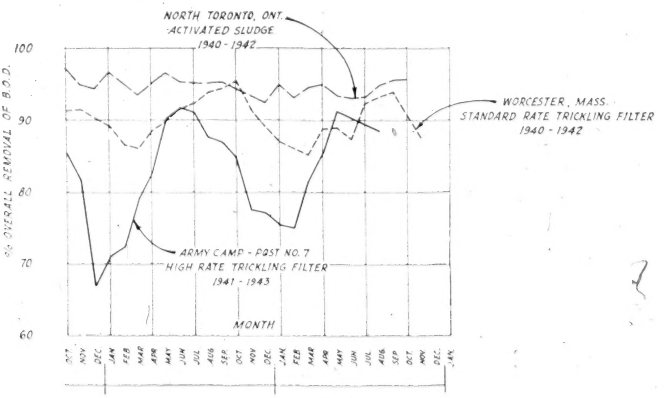
NORTH TORONTO, ONT.
ACTIVATED SLUDGE
1940 - 1942
WORCESTER, MASS.
STANDARD RATE TRICKLING FILTER
1940 - 1942
ARMY CAMP - POST NO. 7
HIGH RATE TRICKLING FILTER
1941 - 1943
% OVERALL REMOVAL OF B.O.D.
100
90
80
70
60
MONTH
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN

FIG. 1.—Variations in removals of B.O.D. by months at certain sewage treatment plants.

and the period of the year—or air temperature—at Post No. 7, for the period from Sept. 1941 to August, 1943, inclusive. While monthly mean air temperatures cover a wider range than do the corresponding sewage temperatures, they may be used in comparison with the B.O.D. removals to emphasize the effect of temperature on bacterial activity. The data for the high rate filter show a marked relation between temperature (as represented by the month) and B.O.D. removal, the change in the latter following closely with change in temperature. A similar trend has been noted in the efficiency of B.O.D. removal as compared with temperature at Post A where single-stage high rate trickling filters are operated also.

For comparison, data are given for two years of operating results from the Worcester, Mass., standard rate trickling filter plant. The Worcester filters have a stone depth of 10 ft. The efficiency of the Worcester plant is likely to be reduced at times because of the deleterious effect of quantities of acid-iron wastes in the sewage. In spite of this abnormality the data plotted indicate that changes in temperature

may have had somewhat less effect on B.O.D. removals than with the high rate filter. There appears to be a lag in the efficiency of this standard rate filter as compared with that of the high rate filter. A similar effect has been noted in the operation of the Fitchburg filters. Possibly this may be due to a sort of storage effect with filters having 10 ft. depth of stone in contrast to the 3 ft. depth of stone in the filters at Post No. 7.

Figure 1 also shows similar data for the North Toronto, Ontario, standard rate activated sludge plant. In this case there appears to be no corresponding reduction in the percentage of B.O.D. removal with lower air temperatures.

Operating data from the standard rate activated sludge plant at Leominster, Mass., indicate a tendency towards increased efficiency during the cold months and a reduction in the summer months, just the opposite of the trend of changes in the trickling filter plants. This might be due to bulking of sludge in the warmer months, or some other effect of bacterial activity encouraged by heat, that tends to reduce overall plant efficiency. Information is not at hand to show whether or not a similar tendency is indicated in the operation of high rate aeration plants. Removals of B.O.D. by plain aeration and by activated sludge treatment at Indianapolis for the years 1937 to 1939, inclusive, according to data published in the annual reports, indicate no trend in percentage removals of B.O.D. either up or down with changes in temperature.

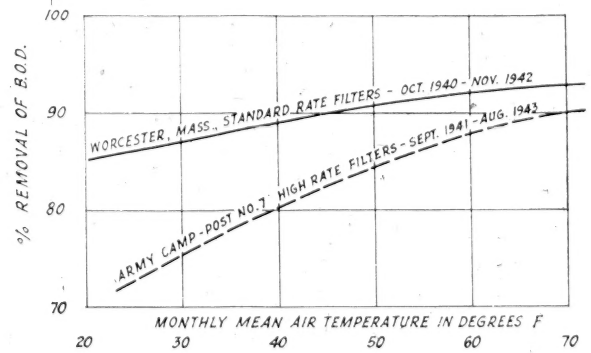

FIG. 2.—General effect of temperature on B.O.D. removals by trickling filter plants.

The effect of temperature, as exaggerated by comparison with that of the air, on B.O.D. removals, with trickling filters of the two general types herein discussed, may be illustrated further by Fig. 2 which indicates that the high rate filter may be more susceptible to changes in efficiency with changes in temperature than the standard rate filter. In plotting this diagram no allowance was made for differences in filter loadings.

If it is true, as indicated by the data here discussed, that the high rate trickling filter is more susceptible to reductions in efficiency as a result of low temperatures than is the case with standard rate filters or with plants using the activated sludge process, this may be a factor in selecting the type of process to use in areas having severe winter temperatures.

Short Period Sewage Aeration

Pilot plant tests carried out at Wards Island Sewage Treatment Plant, New York City, and reported by L. R. Setter, Sewage Works Journal, July, 1943, to which Mr. Greeley referred, indicate that short-period aeration of sewage with some return of final settling tank sludge may furnish a means of obtaining a particular quality of effluent desired between that from plain sedimentation and that from activated sludge treatment. Such a combination process might be of particular advantage where the sewage is relatively weak and seasonal requirements for effluent quality would permit operating at a lower efficiency during the colder months.

PROBLEMS IN THE DESIGN, CONSTRUCTION AND OPERATION OF VERY SMALL SEWAGE DISPOSAL PLANTS *

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Scope

Sewage treatment processes and plants considered in this discussion include only such as are commonly used for the disposal of small quantities of wastes and sewage. The types considered are those that have been of particular value for country estates, schools, institutions, summer camps, hotels and for general housing; all in situations where common sewers are not available. They have been used to a large extent at small Army posts and outposts. The facilities are for the most part out of sight; and if properly designed, constructed and operated, will give satisfactory results with no objectionable odors, over a long period of time and with a minimum of attention.

The smallest unit considered is for a single household. The largest unit would be suitable for a thousand persons in a situation where careful continuous attendance to operation is not reasonably available. For sewage disposal within these limitations, cesspools, septic tanks, tile fields and subsurface filters are commonly used. Intermittent sand filters are occasionally used for the larger units considered where isolation is available and economy of construction is important.

It is recognized that there are situations where the use of Imhoff tanks and trickling filters might well be justified for plants within the limits under consideration. Reference is made to standard texts for the design and operation of such features.

There is much information and also much misinformation with respect to the problems under consideration. It is the intent to review the problems and to consider features of design, construction and operation which appear to be of importance. Special emphasis will be placed on features of the problems concerning which there appear to be material differences of opinion. The problems of the smaller sewage treatment plants have not in general received the consideration and study which has accompanied the development of the various processes in common use for the treatment of municipal sewage.

Data Available in Technical Literature

Many of the textbooks and scientific books on sewage disposal supply more or less information on this subject. In addition, some of the State Health Departments, notably those of New York and Connecticut, supply in pamphlet form general data with regard to small sewage disposal

* Presented before the New England Sewage Works Association, September 22, 1943.

systems. The Massachusetts Department of Public Health makes use of the Engineering Handbook, Soil Conservation Service, August 1940, with some exceptions noted. A report by a committee of the American Public Health Association in 1920, on Rural Sanitation, presents the subject in considerable detail. The most recent noteworthy treatise on the subject is contained in a bulletin issued by the United States Public Health Service, Reprint 2461, March 12, 1943.

Cesspools and Leaching Cesspools

The most common method of disposal of sewage from households and small institutions where disposal into a common sewerage system can not be effected, is in cesspools. Cesspools are usually in the form of a dry-laid masonry well, commonly without any masonry at the bottom. The sewage flows into it and leaches out into the soil. Floating solids collect in the top and settling solids in the bottom of the well. Eventually, the leaching capacity of the well is exhausted as the solids accumulate and clog the soil. It is possible that the life of the ordinary cesspool could be prolonged somewhat if accumulations of solids were removed from the cesspool periodically, as is or should be common practice in the care of septic tanks.

Frequently, when the first cesspool has become filled, a similar second basin is constructed to take the overflow from the first. In such cases, it is desirable to operate the first basin as a septic tank to collect the settling and floating solids and to provide a trapped outlet on the connection leading to the second or subsequent leaching cesspools. Septic tanks may advantageously be placed ahead of leaching cesspools in larger installations. Some authorities recommend that leaching cesspools be placed not closer than 20 feet apart out to out of walls.

Leaching cesspools are most applicable for locations where the subsoil is porous to a depth of 8 or 10 feet at least and where the groundwater table is normally below this elevation. Where located in fine sand, it has been found advantageous to surround the walls with graded gravel, thus in effect increasing the leaching area.

The total number and size of cesspools is dependent upon the quantity of sewage requiring disposal and the leaching characteristics of the total superficial percolating area above the groundwater table in square feet, including bottoms and exterior side walls below the maximum flow lines. The allowable rate of sewage application per sq. ft. per day based on the recommended leaching test, as given by the New York State Department of Health, is as follows:

Time for Water to Fall 1 Inch (Minutes)	Allowable Rate of Sewage Application Gallons per Sq. Ft. of Percolating Area per Day
1	5.3
2	4.3
5	3.2
10	2.3
30	1.1
60	0.9

Leaching Test

The test for leaching should be made by first digging a pit to a depth of about one-half the proposed depth of the cesspool, and then digging a test hole 1 foot square and 18 inches deep. The hole should be filled with water to a depth of 6 inches and the water allowed to drain off. Water to a depth of 6 inches should again be added and the downward rate of percolation or drop of water surface should then be observed by taking the time in minutes for the water surface to lower 1 inch in the hole.

Septic Tanks

The primary purpose of the septic tank is the collection of settling and floating solids. They are commonly designed to operate for 6 months to a year without removal of solids, and therefore should be designed of sufficient capacity to provide storage space for the accumulating solids and still leave residual capacity for efficient separation of solids from the sewage. Adequate capacity is the critical criterion of design, although a few details of design are of considerable importance.

The following basis of design is suggested as reasonable for normal conditions:

In general for sewage flows of less than 1,500 gallons per day, the effective septic tank capacity should be equal to a full day's flow; the minimum desirable size being 500 gallons. With sewage flow in excess of 4,000 gallons per day, the effective capacity should be at least equal to 10 hours' flow plus an allowance of 2.5 cu. ft. per capita of sludge capacity. For intermediate flows between 1,500 and 4,000 gallons, the capacity should be appropriately adjusted.

Details of design which are considered of importance in securing efficient operation include the following:

1. It is desirable to have a minimum of 3-inch freeboard between the water level in the tank and the invert of the sewer inlet. This is to combat the tendency of scum collections to block the inlet opening.
2. Baffles should be provided at the inlet to disperse the sewage flow in the tank and at the outlet to retain floating solids, which would otherwise discharge with the effluent.
3. Access openings should be provided to the ground surface. When access openings are buried, there is a tendency to neglect the periodical removal of solids required for efficient operation of the tanks. These openings should be of sufficient size to permit entrance. In tanks of any size it has been found advisable to have openings located over the inlet and outlet connections, permitting inspection and removal of stoppages at these points.
4. Smaller tanks should have a water depth of at least three feet and some authorities recommend a minimum of four feet. It is believed advisable to use rectangular tanks with the length from two to three times the width. Small circular units are not recommended and it is not

believed advisable to provide several small units in place of a single tank of equivalent capacity.

5. The majority of septic tanks are constructed with flat horizontal bottoms. However, some authorities recommend a sloping bottom to facilitate sludge removal.

6. Open vents from the septic tank are unnecessary and undesirable. If installed, they permit the escape of objectionable odors and provide an access for flies and mosquitoes and an excellent breeding place for them.

There is no truth to statements or claims made that septic tanks dissolve all solids; that they never need to be cleaned and that the liquid leaving them is pure and free from germs. It is probable that on the average about 50 to 60 per cent of the suspended solids may be retained, leaving 40 to 50 per cent to be discharged in the effluent. The liquid from them may putrefy and give off odors if not suitably disposed of and is heavily laden with bacteria.

In general, septic tanks should be followed by leaching cesspools, tile fields or subsurface filters.

Materials removed from septic tanks and from cesspools contain partially digested sewage solids and should only be disposed of where there is no resultant danger to the public health. Disposal through manholes in the nearest sewerage system as approved by the local authorities, or burial in shallow furrows on farm land, is to be recommended.

In the interests of economy for projects of a temporary nature, the Army has used wood to a considerable extent in the construction of septic tanks. The wood is creosoted by the double dipping process and the cover is protected by heavy roofing paper.

Sludge Drying Beds

In some instances, the provision of sand beds for unwatering the sludge and scum removed from septic tanks may be found advisable. The septic tanks are designed to operate for 6 to 12 months without removal of solids, and when cleaned, it is customary to remove all of the solid materials. Under such conditions, the sludge beds should have an area equivalent to 6 or more sq. ft. per capita.

Sludge beds are commonly constructed of sand, 12 to 18 inches deep. In small installations, underdrains are not required. For large plants, if the underlying soil is relatively impervious, it may be found advantageous to provide underdrains discharging to the open ground.

Tile Fields

Tile fields consist of lines of vitrified pipe laid in the ground with open joints. They may be used for the disposal of settled sewage into the ground.

In order to have tile fields function properly, the following factors are important:

1. Ground water well below the level of the tile field.
2. A soil of satisfactory leaching characteristics, within a few feet of the surface, extending to a depth of several feet below the tile and with subsurface drainage away from the field.
3. Adequate area.
4. Absence of any opportunity to pollute drinking water supplies, particularly from shallow dug or driven wells in the vicinity.

In general, the length of tile and details of the filter trench will depend upon the character of the soil. Soil leaching tests should be made at the site in the same manner as described for leaching cesspools, except that the test hole should only extend to the approximate depth at which the tile fingers will be laid. For extensive tile fields, it is advisable to make several tests to determine the best location for the field and the average conditions in the selected location. With results of the test available, the rate at which the sewage may be applied to the total superficial bottom area of the trenches in which the tile is to be laid, may be taken from the following table:

Time for Water to Fall 1 Inch (Minutes)	Allowable Rate of Sewage Application Gallons per Sq. Ft. per Day, Bottom of Trench in Tile Field
1	4.0
2	3.2
5	2.4
10	1.7
30	0.8
60	0.6

As a further check on the suitability of the soil in which the subsurface tile system is to be placed, a test may be made to determine its effective size and uniformity coefficient. It is desirable for the effective size to be above 0.20 mm. Materials below this size cannot pass sufficient quantities of sewage and tend to clog quickly. If the soil is tight, consideration should be given to underdrained filter trenches or to subsurface filters.

Details of Design

There has been some misconception about the necessity of placing the tile in the field below the frost line to prevent freezing in the New England area during the winter. A large number of such fields, in which the tile is placed on the average 18 inches below the ground surface, have been operating successfully in New England for many years.

Having in mind the volume of sewage solids discharging in the effluent from the septic tank, the design and construction should provide for the handling and storage of solid material, eliminating insofar as practical, opportunity for clogging at the pipe joints or immediately adjacent thereto. While four-inch pipe is commonly used, it is suggested that six-inch pipe is preferable, as it affords much greater storage capacity for solids which tend to accumulate in the pipe and a larger area of opening at the joint for solids to escape into the surrounding gravel.

In order to provide for free discharge of solids from the tile pipe line to the filter trench, it is recommended that the pipe be laid with a ⅜-inch clear opening between pipes. The use of bell and spigot pipe is recommended as helpful in laying the pipe to true line and grade. It is believed good practice to break away two-thirds of the bell at the joint and to use a small wooden block spacer. The pipe is commonly laid at a slope of about 0.5 per cent when taking the discharge directly from the septic tank and at a slope of 0.3 per cent when a dosing tank is used ahead of the field.

Some authorities advocate laying the tile directly in porous soil without surrounding the pipe with coarse gravel. In other cases, bank run gravel or graded gravel containing a large percentage of fines has been called for and used. Again having in mind the quantity of solids in the sewage reaching the tile field, it is recommended that the tile be laid on a bed of screened coarse gravel 6 inches deep and that coarse gravel be placed around the pipe and over the pipe to a depth of at least 3 inches. Coarse screened stone passing a 2½-inch mesh and retained on a ¾-inch mesh is recommended for this service. This volume of coarse screened gravel affords a relatively large percentage of voids into which the solids may pass and collect before the effective leaching area becomes seriously clogged.

Provision must be made for preventing the soil with which the trench is subsequently filled from filling the voids in the coarse screened gravel around the pipe. Some authorities recommend a layer of hay and others prefer tar or building paper laid over the stone to the full width of the trench. The practice of some engineers is to place a three-inch layer of medium screened gravel over the coarse stone and 3 inches of either fine screened gravel or suitable bank run gravel over the medium stone.

The layout of the tile in the field should be carefully designed. It is recommended that in general the length of lateral fingers be not greater than 75 feet. When the tile field is laid in sloping ground, it is advisable to distribute the flow in such manner that each finger will get a fair portion of the flow and especially to prevent the flow from discharging down the slope to the lowest point. Tile fields are commonly laid out in either a "herring bone" pattern or with the laterals at right angles to the main distributor. The laterals should be from 6 to 10 feet apart on centers. Some authorities recommend the use of distribution boxes to which the laterals are connected.

Some authorities recommend an eighteen-inch width of leaching trench. It is believed more economical to provide a trench 24 inches or wider. Where the operation of a trenching machine is practical on a large installation, the design should be based on the width of trench excavated by the machine.

Once a tile field is constructed, it is advisable to exclude heavy traffic from the area, especially in a shallow field. The planting of shrubs or trees over the field is not considered good practice.

A typical section of a tile filter trench is shown in Fig. 1. A typical layout of a tile field on sloping ground is shown in Fig. 2.

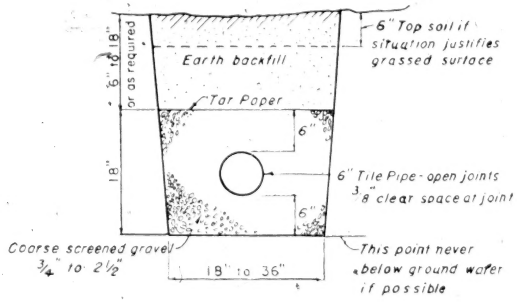
6" Top soil if situation justifies grassed surface
Earth backfill
Tar Paper
6" to 18" or as required
18"
6"
6"
6" Tile Pipe - open joints 3/8" clear space at joint
Coarse screened gravel 3/4" to 2 1/2"
18" to 36"
This point never below ground water if possible

FIG. 1.—Typical section of filter trench.

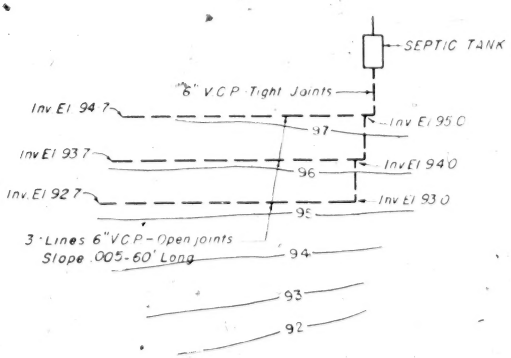

FIG. 2.—Typical layout of tile field on sloping ground.

TREATMENT OF KITCHEN WASTES

Some authorities have advocated the treatment of kitchen wastes by only a grease trap and then discharging the wastes directly to the tile field, bypassing the septic tank provided for the sewage. Tests have demonstrated that a large quantity of grease and solids passes through the grease trap. These solids tend to clog the tile field. They can in considerable measure be retained in a properly operated septic tank. It is recommended that kitchen wastes after passing through the grease trap be treated in a septic or other settling tank prior to discharge into the tile field. The kitchen wastes may be treated in the same tank as provided for other sewage flows. There is no action going on in the septic tank which will be deleteriously affected by the introduction of kitchen wastes.

Subsurface Filters

Where the soil is so dense and impervious as to make the use of a subsurface tile trench system impractical, and where an open filter is not advisable because of lack of isolation, subsurface filter trenches or beds may be required. Underdrains from subsurface filter trenches or beds should discharge freely to the nearest satisfactory point of disposal.

The filter trenches or beds should be designed for a rate of filtration not greater than 50,000 gallons per acre per day or 1.15 gallons per sq. ft. per day. The filtering material should be clean, coarse sand all passing a ¼-mesh screen and having an effective size between 0.25 and 0.5 mm., and a uniformity coefficient not greater than 4.0. The depth of filtering sand should as a general rule be not less than 30 inches. Coarse

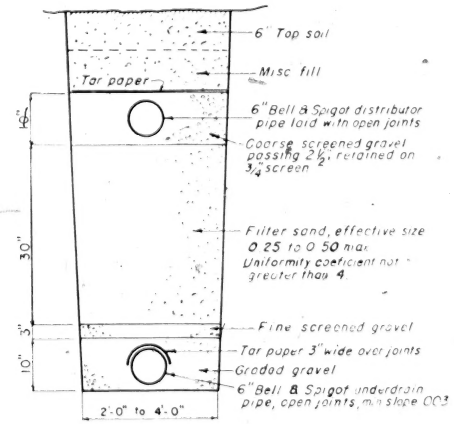
6" Top soil
Misc fill
Tar paper
6"
6" Bell & Spigot distributor pipe laid with open joints
Coarse screened gravel passing 2½" retained on ¾" screen
30"
Filter sand, effective size 0.25 to 0.50 max. Uniformity coefficient not greater than 4
3"
Fine screened gravel
10"
Tar paper 3" wide over joints
Graded gravel
6" Bell & Spigot underdrain pipe, open joints, min slope .003
2'-0" to 4'-0"

Fig. 3.—Typical section of underdrained filter trench.

screened gravel should pass a 2½-inch mesh and be retained on a ¾-inch mesh.

A typical section of an underdrained filter trench is shown in Fig. 3. Governing conditions for the layout of the field are similar to those for the tile fields previously described.

A typical plan and section for a subsurface filter are shown in Fig. 4. The slope of the distributors should be about 0.3 per cent when a dosing tank is used or 0.5 per cent when no dosing tank is required. Some authorities recommend the distribution pipes be laid without slope when a dosing tank is provided. For installations having more than 800 feet of distributors, it is desirable to construct the filter in two or more sections with alternating siphons to alternate the flow to the different sections.

Intermittent Sand Filters

Where there is suitable isolation, an intermittent sand filter will be more economical to construct than a subsurface filter and should have a much longer life in that the accumulations of sludge and the top layer

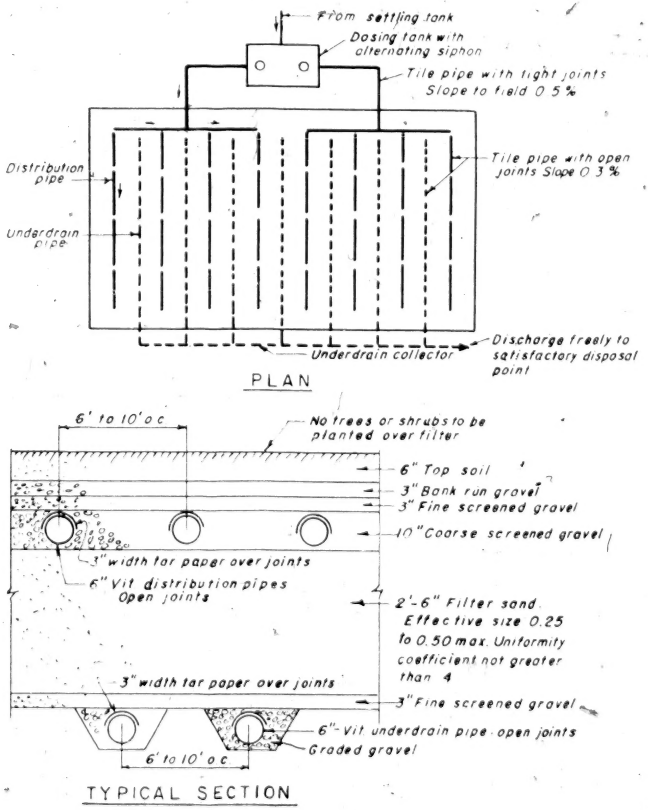
From settling tank
Dosing tank with alternating siphon
Tile pipe with tight joints Slope to field 0.5%
Distribution pipe
Tile pipe with open joints Slope 0.3%
Underdrain pipe
Underdrain collector
Discharge freely to satisfactory disposal point
PLAN
6' to 10' o.c.
No trees or shrubs to be planted over filter
6" Top soil
3" Bank run gravel
3" Fine screened gravel
10" Coarse screened gravel
3" width tar paper over joints
6" Vit distribution pipes Open joints
2'-6" Filter sand Effective size 0.25 to 0.50 max. Uniformity coefficient not greater than 4
3" width tar paper over joints
3" Fine screened gravel
6" Vit underdrain pipe open joints
Graded gravel
6' to 10' o.c.
TYPICAL SECTION

Fig. 4.—Typical plan and section of subsurface sand filter.

of dirty sand can be removed periodically, as required to maintain the bed for many years substantially up to its designed capacity.

The design of intermittent sand filters is well established and for detailed data reference is made to the chapter devoted to the subject in Metcalf & Eddy's "American Sewerage Practice," Volume III, "Sewage Disposal." Briefly, for installations of the size considered in this paper, the following basic design data are suggested:

Filter loading—75,000 to 100,000 gallons per day
Depth of bed—3 to 4 feet of sand over the underdrains
Dosing tanks shall be provided designed to cover the bed to a depth of 1 to 3 inches at each discharge
Effective size of sand—0.20 to 0.35 mm.
Number of beds—minimum of 2
Spacing of lateral underdrains—10 to 20 feet

The cost of intermittent filter beds will be greatly reduced if suitable sand can be found in place and the topsoil stripped off to form the embankments. It may be practical and economical to construct the beds of materials found in place even though the effective size is as low as .15 mm. in which case the unit loading should be reduced to 50,000 gallons per acre per day. If the area is well drained, underdrains may not be required.

Use of Dosing Tanks in Conjunction with Filters

Dosing tanks with automatic sewage siphons should be provided for tile fields when the length of distribution tile exceeds 300 feet, for a subsurface or open filter having an area in excess of 1,800 sq. ft. Dosing tanks should be designed to discharge a volume equal to 70 to 80 per cent of the volumetric capacity of the distribution piping in the tile field or filter. The dosing tank can usually be constructed as a part of the septic tank. The high water level should be not less than 3 inches below the level of the sewage in the septic tank.

Reference should be made to the manufacturers' bulletins for standard capacities and details of sewage siphons.

Summary

Experience has shown that the design and construction of small sewage disposal facilities have too frequently been accomplished without proper regard to the requirements thereof.

There is much misconception concerning the operation of septic tanks and much misinformation with respect to the design and layout of tile fields.

While there may be some differences of opinion as to the best method and details for solving the problems of sewage disposal in small installations coming under the scope of this paper, it is believed that the material presented affords a reasonable approach to the problems.

Discussion

By Edward Wright

Sanitary Engineer, Massachusetts Department of Public Health

A great impetus in the construction of small sewage disposal problems has been occasioned by the war. This is particularly so in the east-

ern part of the State where examinations have been made of somewhat over 50 small military and naval establishments located in comparatively isolated areas. In addition, reference can be made to some 85 Coast Guard installations along the coast also located in isolated areas where for the most part local water supplies and local means of sewage disposal have been required. The Department has been much concerned over the disposal of sewage at certain Federal Housing Administration projects and has assisted architects and engineers of that organization in the preparation of plans for sewage disposal systems. A sanitary engineer from the U. S. Public Health Service has recently been assigned to each of the Federal Housing Districts and it is believed that improvements in sewage disposal at these housing developments can now be expected. In most instances the means of sewage disposal at these Federal installations have consisted of septic tanks with subsurface tile fields. Porous soil is quite generally found in Massachusetts. In a few instances, however, the sewage from military or naval establishments has been discharged directly into tidal waters and it has been necessary for the Massachusetts Department of Public Health to close two small shellfish areas in Buzzards Bay, one in Scituate, and two in Falmouth because of the direct discharge of sewage to shellfish producing areas. In addition, the Department has been much concerned relative to the pollution of the valuable oyster areas at Cape Cod where various army camps have been established, particularly in connection with amphibian training. Thus far, no serious pollution of the oyster areas from these camps appears to have occurred. On the other hand, there is reason to believe that the activities in these tidal areas have been such as to interfere with the normal feeding habits of oysters.

Good co-operation in the construction of small sewage disposal units has been experienced with the army officers of the First Service Command and the Corps of Engineers both in the Boston and Providence offices and members of the Division of Sanitary Engineering have become quite well acquainted with some of the engineering personnel of the Navy and Coast Guard in the First Naval District. Unfortunately, early in the war, the sanitary engineering advice available to the Navy on sewage disposal was not of great value. Plumbers were engaged to design and construct septic tanks and in some instances septic tanks, having flowing-through periods of 24 or more hours, have been established with flat bottoms and no means whatsoever for cleaning. In several instances, it has been necessary to rebuild the tanks, to make provision for sludge removal and to advise as to methods of operation. In some instances chlorinators have been provided but no chlorine. In one instance, the scale for weighing the chlorine cylinders was moved to another part of the camp and no check on the amount of chlorine applied was available. In certain instances, septic tanks have been found to be full of sludge with the fresh sewage flowing over the surface. In some cases, barrel chlorinators have not received adequate attention. In other cases, water connections have not been provided. In one or more in-

stances, contracts have been let for septic tank cleaning with arrangements to discharge the sludge into municipal sewers but it is the writer's feeling that the contractors are using the sludge for fertilizer purposes or disposing of it on land rather than discharging it into sewers. This is a sewage disposal problem requiring more and more attention of health authorities. Very few arrangements for the discharge of night soil into municipal sewers have been provided. One in Lynn which was well designed is not now being used. In one naval establishment, a contract had been let for a single cleaning of septic tanks at a cost of $1,500. The writer was recently informed that Charles L. Poole, former Sanitary Engineer and Chemist, State Department of Health of Rhode Island, has recently been appointed as a Navy Officer to set up in the Navy what corresponds to the Sanitary Corps in the Army. Thus, improved sewage disposal conditions at naval installations can be expected.

Mr. Arthur D. Weston, Chief of the Division of Sanitary Engineering, was requested some time ago to prepare basic design data for emergency sewage treatment works, the request coming from the Navy Department in Washington. The design data do not fall within the scope of this discussion with the exception of the last paragraph wherein the Division has recommended that cesspools, septic tanks and subsurface disposal systems are not advisable for populations in excess of 50 to 100 persons.

Generally, the uninformed public feels that a septic tank, sometimes in ordinary parlance called a "skeptic" tank, should be installed, presumably after having been approached by a commercial manufacturer of septic tanks. The writer is serious in the use of the term "skeptic" as no bulletins of design based on research or experimental works have appeared until lately. Many manufacturers and the public seem to think that a septic tank is the cure-all for local sewage disposal problems but they do not realize that sewage consists of more than 95 per cent water and some form of subsurface disposal either by cesspools or finger drains is necessary. These are not always mentioned in the advertisements. In addition, grease traps other than small sink grease traps are rarely installed and grease is generally the cause of much of the difficulty in clogging subsurface works. Suitable grease traps should always be installed and should be properly maintained. Up to 1940, the Department rather generally referred individuals to an early Farmer's Bulletin issued by the U. S. Department of Agriculture. An investigation was made by Federal authorities in the late 1930's with the result that the U. S. Department of Agriculture, Soil Conservation Service, issued a new set of standards in rural sewage disposal in 1940 with numerous diagrams. This set of standards has been mimeographed by the Department and is available for distribution.

Still feeling that the whole question of small sewage disposal units needed more study and in order to co-ordinate the recommendations of various Federal and other bureaus having to do with sewage disposal, a Joint Committee on Rural Sanitation was formed on June 17, 1941, consisting of Sanitary Engineers representing the U. S. Department of

Agriculture, Bureaus of Chemistry and Engineering, Extension Service, the Farm Security Administration, the Forest Service, Rural Electrification and Soil Conservation Service. The Committee included a representative of the Conference of State Sanitary Engineers together with the Sanitary Engineer of the Federal Housing Administration, two engineers of the U. S. Public Health Service and the Sanitary Engineer of the Tennessee Valley Authority. The results of this study appear in Reprint 2461, March 12, 1943, U. S. Public Health Service, which seems to be the last word in rural sewage disposal. Some of the data therein presented are given in rather a too complicated manner for rural use.

In view of the fact that subsurface distribution systems in this part of the country appear to be the most reasonable means of sewage disposal in small units, the tables appearing on page 19 of this pamphlet are of considerable importance. One of these tables has been summarized in comparatively simple terms as follows:

Data for Determining Length of Subsurface Distribution Pipes from Percolation Tests (Residences)

Time in Minutes for Water to Fall One Inch	Length of Subsurface Distribution Pipes in Feet per Person in Trenches 24 Inches Wide
2 or less	13
3	15
4	18
5	20
10	26
15	31
30	45
60	60
Over 60	Special design using seepage pits or sand filter trenches

Minimum *total length* per family dwelling unit 75 feet.

Note: Based on 50 gallons per person. Number of persons should be according to the maximum living capacity of the building.

The writer's objection to this publication is the so-called absorption test. To be sure, it is used quite generally in various parts of the country but a mechanical analysis of the soil is so simple and the absorption of clean water in dry soils so variable that a mechanical analysis would appear to be desirable in each instance, so far as practicable, at least in corroboration with the absorption test.

Feeling that more should be learned in regard to small sewage disposal installations, the Division of Sanitary Engineering of the Department, several years ago, constructed four septic tanks at the Lawrence Experiment Station. These tanks are 2 feet wide and 40 inches deep. One has a capacity of 185 gallons and the other three are made up of two compartments, each with a capacity of 185 gallons. One tank, No. 507, is used for the treatment of fresh domestic sewage from the station and the others are used for the regular Lawrence sewage. They are

provided with baffles extending to within about 8 inches of the bottom. The results of these experiments are described in the various annual reports of the Department, the latest reference being to the mimeographed copy of the 1941 report, page L–9. The operation of these septic tanks and more recently the subsurface distribution systems are under the control of the chemists at the Lawrence Experiment Station. The results of the analytical data are summarized as follows:

Operation of Septic Tanks

Tank No.	Detention Period (Days)	Per Cent Removal Dissolved B.O.D.	Per Cent Removal Suspended Solids	Per Cent Removal Bacteria 4 Days – 20° C.	Per Cent Sludge Destroyed in One Year
691	½	31	62	35	74
507	2	44	87	35	64
508	2	48	72	42	38
690	6	63	72	20	38

The effluents still carried total counts of well over a million bacteria per cc. and gave off offensive odors.

The septic tanks show a removal of 54 to 83 per cent of fats. Quite recently, further experiments have been inaugurated in septic tank and subsurface disposal at Massachusetts State College, at Amherst, which are being carried out by the college under the general direction of the Department. Thus, we are learning something about small sewage disposal units.

Industrial Wastes

NEUTRALIZATION OF ACID WASTE WATERS WITH AN UP-FLOW EXPANDED LIMESTONE BED*

By Harry W. Gehm

Assoc., Dept. Water and Sewage Research

A number of industries discharge relatively dilute acid waste waters into inland waters. Foremost among these are explosive manufacturing processes, general pharmaceutical productive processes, chemical production and steel pickling. War requirements have increased the need for the materials productive of these wastes to an enormous degree. In many cases such discharge has inhibited severely the self-purification capacity of the bodies of water into which they are discharged.

Neutralization of these acid wastes as a means of rendering them innoxious has been resorted to in a number of instances. Simple though this procedure may seem, a number of factors enter the picture which complicate the problem, and to produce a continuously neutral effluent free of precipitate, without waste of neutralizing agent requires rather elaborate equipment and continuous supervision and control. One such device is described by Rudolfs (1).

Considerable attention has been given to the use of lime products as neutralizing agents because of their low cost. The greatest shortcoming of them has been the fact that calcium sulfate precipitated when sulfuric acid concentrations were relatively high, thus producing a sludge problem. Rudolfs (2) reported on extensive experimental work in employing lime products for treatment of acid wastes and showed definitely that they could be advantageously employed both alone and in combination with soda-ash.

Nitro-Cellulose Waste

The waste produced from the manufacture of nitro-cellulose consists mainly of a dilute mixture of nitric and sulfuric acids with a very small quantity of nitro-cellulose fiber in suspension. These factors plus the fact that it is one of the largest offending waste waters made it an ideal acid waste with which to work. Samples of such waste obtained from plants producing this product contained around 12,000 p.p.m. of acidity as $CaCO_3$, about one-third in the form of nitric and two-thirds in the form of sulfuric acid.

Previously published results (2) dealing with the treatment of this waste with lime products demonstrated that pulverized limestone, the least expensive neutralizing agent, could be employed for neutralization. Two general limitations existed in its use; namely, considerable sludge

* Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Water and Sewage Research, New Brunswick, New Jersey.

is formed on account of the precipitation of calcium sulfate and good control of such treatment requires large and extensive equipment and considerable personnel.

The use of limestone beds for treatment of such waste is attractive because they are simple to construct and require little control. However, such beds are generally quickly rendered ineffective by the depositing of calcium sulfate on the stone and must be large in area in relation to the volume of waste handled to effect complete neutralization of the mineral acids.

The purpose of the studies reported here was to apply limestone to the neutralization of nitro-cellulose waste in a manner designed to overcome the limitations, so that without extensive equipment or continuous attendance, complete and continuous neutralization could be effected without waste of neutralizing agent.

Preliminary Tests

Experiments were first made involving the application of high calcium limestone to a waste containing a mineral acidity of 12,400 p.p.m. $CaCO_3$, 4,250 p.p.m. of which was due to nitric and 8,150 p.p.m. due to sulfuric acid. Liter portions of the waste were stirred rapidly for fifteen minutes after addition of varied dosages of pulverized high calcium limestone. The pH and mineral acidity of the treated waste were determined and the volumes of the sludge formed after 8 hours settling recorded. Results of these trials as to neutralization and sludge formation are plotted in Fig. 1 together with corresponding pH changes.

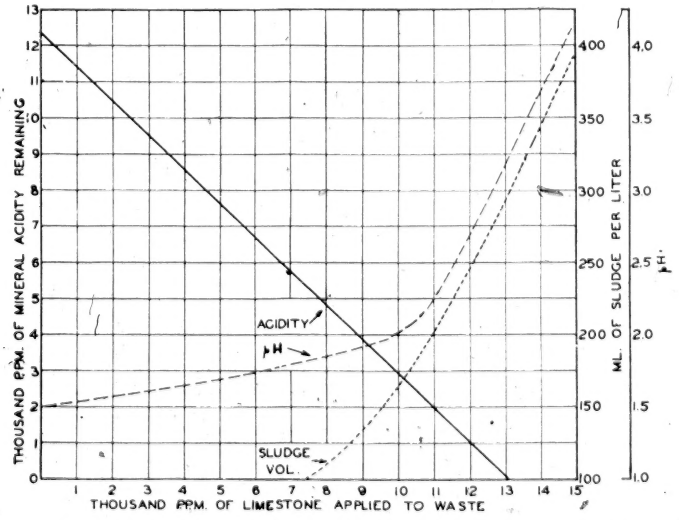

Fig. 1.—Neutralization of nitro-cellulose waste with high calcium limestone.

It was evident from these results that the mineral acidity could be reduced from 12,400 p.p.m. to 5,250 p.p.m. before any appreciable amount of sludge was formed. The fact that calcium nitrate, formed from the reaction of the limestone with the nitric acid, is soluble, accounts for the neutralization of 4,250 p.p.m. of the mineral acidity without sludge formation. About 2,900 p.p.m. of mineral acidity neutralized under these conditions represents sulfuric acid neutralization with the resulting calcium sulfate formed remaining in solution. This acidity converted to a calcium sulfate basis represents 3,944 p.p.m. of $CaSO_4$. The solubility of calcium sulfate in water under these conditions was 1,900 p.p.m. This figure is slightly lowered by the presence of calcium nitrate. Thus a supersaturation of calcium sulfate exists probably due to the method of formation. It appears that neutralization of all the nitric acid and at least a portion of the sulfuric acid acidity, equivalent at least to the solubility of calcium sulfate in water (1,400 p.p.m. as $CaCO_3$), under these conditions, can be neutralized without sludge formation. This would amount to a total of 5,650 p.p.m. mineral acidity. Additional experiments showed that waste samples neutralized to this degree and even to a greater extent were definitely stable in regard to calcium sulfate precipitation when subjected to agitation or long standing. As such waste can often be discharged into diluting waters quickly after treatment it is possible that neutralized waste could carry super-saturations of calcium sulfate without its precipitation.

It is obvious that if crushed dolomite replaced the high calcium limestone a greater degree of neutralization without sludge formation could be obtained because practically half the sulfuric acid acidity would be spent in the formation of soluble magnesium sulfate. Numerous trials using this material showed, however, that it reacted too slowly for practical purposes and hence was not suitable.

Calculations showed that if a dilution of the waste were made with sufficient water from the receiving stream to lower the mineral acidity to about 4,000 p.p.m. prior to treatment, sludge formation could be prevented. A series of experiments were made in which the same waste previously employed was diluted with tap water to various degrees and then treated with sufficient calcium carbonate to complete neutralization. The procedure for treatment and analyses was the same as the one previously followed.

Data presented in Table I indicates that, to prevent calcium sulfate precipitation, a dilution of 200 per cent was required or two volumes of water to one volume of waste. The concentration of calcium sulfate remaining in solution after such dilution and treatment was 3,694 p.p.m., which checked results obtained on partial treatment of undiluted waste.

Limestone Bed Treatment

In neutralizing acid wastes, such as nitro-cellulose waste water, in limestone beds, the reaction takes place at the surface of the stone. The rate of reaction depends upon the surface available which in turn depends upon the size of the stone particles. Another factor which must

TABLE I.—*Treatment of Diluted Nitro-Cellulose Waste*

Dilution (Per Cent)	Mineral Acidity of Diluted Waste (p.p.m.)	Sludge per Liter Diluted Waste (ml.)	$CaSO_4$ Formed (p.p.m.)	Mineral Acidity Remaining (p.p.m.)
0	12,400	400	11,084	0
25	9,920	200	8,868	0
50	8,264	150	7,342	0
75	7,108	120	6,332	0
100	6,200	100	5,542	0
125	5,512	20	4,928	0
150	4,960	2	4,434	0
200	4,133	0	3,694	0
250	3,542	0	3,166	0
300	3,100	0	2,771	0

be considered is the binding of the surface of the stone with carbon dioxide gas liberated by the reaction. Precipitation of some calcium sulfate and the residue of impurities left by the dissolved stone also affect the reactiveness and permeability of such a bed.

After numerous and not very promising results with downflow type beds it was decided to try up-flow treatment in the hope that neutralization could be obtained at sufficiently high rates of waste passage and without excessive depth of stone to eliminate the several difficulties experienced with the down-flow bed.

An up-flow filter was constructed in the manner shown in Fig. 2. The tube had a cross sectional area of one square inch and was filled to a depth of two feet with high calcium limestone, ten mesh screenings caught on 20-mesh screens being used.

Calcite was the first stone employed. The reservoir was filled with waste of 12,400 p.p.m. mineral acidity diluted with tap water to give an acidity of 5,660 p.p.m. Portions of the waste were then passed through the bed at several rates, care being taken to pass sufficient waste through for stabilization to take place prior to sampling and measuring rate of passage. Mineral acidity, pH, rate of passage and expansion of the bed were recorded.

It was quickly recognized that this type of bed could operate continuously and neutralize completely at rates equivalent and higher than those used to back wash the standard rapid sand filters employed in water works practice. Residues from the dissolved stone and any gases liberated were swept from the bed. Carbon dioxide formed by the reaction did not accumulate in the stone, but was swept out by the rapid flow. Typical results of a run through a bed of 10- to 20-mesh calcite two feet in depth, applying the waste diluted to such an extent that it contained 5,660 p.p.m. of mineral acidity, are shown in Table II. A bed of this depth was capable of neutralizing all the mineral acidity in the waste at an application rate of 56.4 gallons per square foot per minute. Raising the rate to 60 gallons per square foot per minute produced neutralization of all but 28 p.p.m. of the mineral acidity present. When lower rates than 56.4 gallons per square foot per minute were employed

bicarbonate alkalinity appeared in the waste and the pH was raised above 4.2. However, substantial reduction in rate of flow was necessary before appreciable alkalinity appeared.

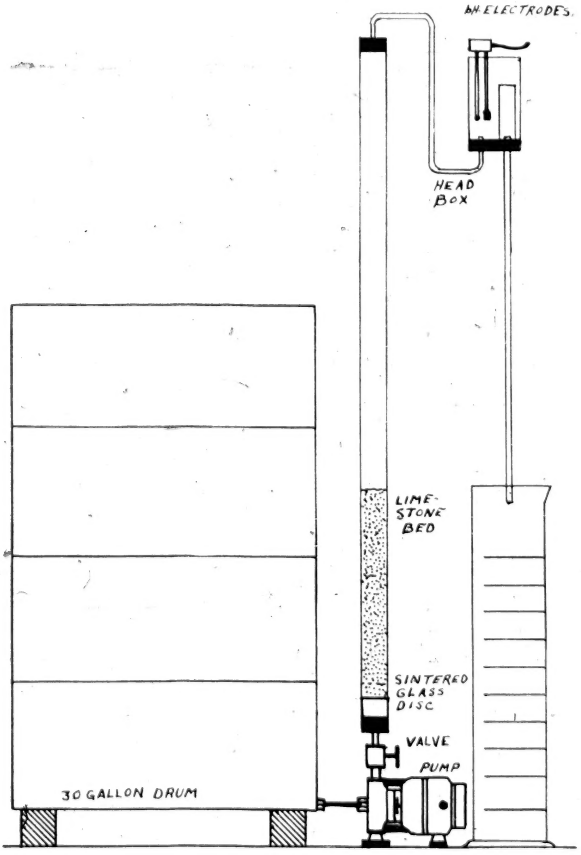

FIG. 2.—Apparatus employed for upflow bed experiments.

In view of these results the effect of various physical and chemical factors in relation to the process were studied. The factors studied were:

1. Type of stone
2. Bed depth
3. Acidity of waste
4. Size of stone

TABLE II.—*Treatment of Diluted Waste on Calcite Up-Flow Expansion Bed*
Waste—5,660 p.p.m. Mineral Acidity

Rate of Application (g. per sq. ft. min.)	Effluent pH	Effluent Mineral Acidity (p.p.m.)	Effluent Alkalinity (p.p.m.)
21.6	5.4	0	50
45.6	5.0	0	42
52.8	4.9	0	27
56.4	4.2	0	0
60.0	4.0	28	0

1. *Type of Stone*

Calcite and an amorphous limestone were compared for their neutralizing ability. Columns of 2 to 3 mm. diameter stones, one foot deep, and weighing 250 grams, were compared. Waste diluted to the same degree and having a mineral acidity of 2,950 p.p.m. was applied at varied rates.

TABLE III.—*Effect of Type of Stone*

Calcite Stone				Amorphous Stone			
Application Rate (g. per sq. ft. min.)	pH Effluent	Alkalinity (p.p.m.)	Mineral Acidity (p.p.m.)	Application Rate (g. per sq. ft. min.)	pH Effluent	Alkalinity (p.p.m.)	Mineral Acidity (p.p.m.)
16.9	4.7	45	0	15.8	4.8	138	0
19.6	4.5	15	0	18.4	4.5	114	0
21.2	4.2	0	0	21.6	4.2	0	0
24.4	3.8	0	40	25.6	3.8	0	22
34.0	2.7	0	100	44.0	2.6	0	41

Mineral Acidity of Diluted Waste = 2,950 p.p.m.

Note: Stone 2–3 mm. diameter; bed 1 foot deep.

The comparative results are given in Table III. As far as pH is concerned, the two types of stone produced practically identical results. Judging from the acidity-alkalinity results it appears that the amorphous stone was somewhat more readily soluble.

2. *Effect of Depth of Bed on Rate of Application of Waste*

Calcite beds of 0.5, 1 and 2 and 3 feet were prepared with stone (passing 10, caught on 20-mesh) of 1.4 mm. average diameter. Waste diluted to a mineral acidity of 4,240 p.p.m. was applied to each and the rate adjusted until a pH of 4.2, indicating complete neutralization of mineral acidity, was obtained. The rates obtained are shown plotted against the bed depths in Fig. 3. It is readily observed that the relationship between the two, for bed depths greater than 12 inches, is practically linear.

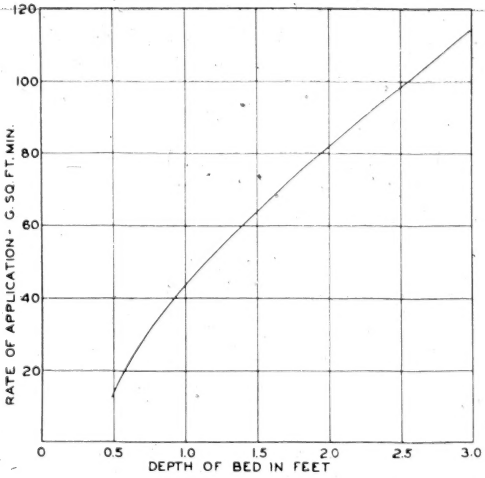

FIG. 3.—Affect of bed depth on rate of application of nitro-cellulose waste to up-flow bed.

3. *Effect of Acidity of Waste*

Several expansion beds containing a depth of one foot of calcite stone, having a diameter varying from 2 to 3 mm. were used. Waste diluted to various degrees were passed through these beds and the rate

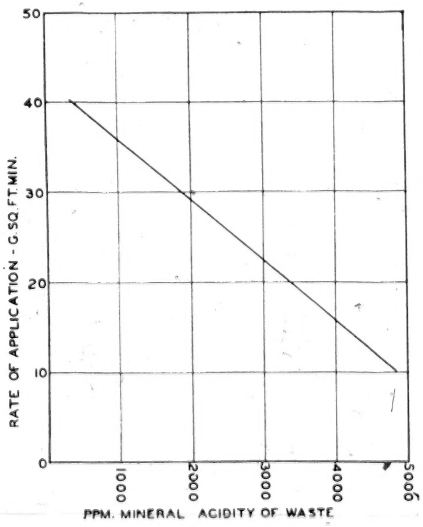

FIG. 4.—Affect of waste acidity on rate of application of nitro-cellulose waste to up-flow bed.

adjusted until an effluent pH of 4.2 was obtained with each dilution, indicating complete neutralization of the mineral acidity present. The rates obtained in relation to the mineral acidity of the waste applied is plotted in Fig. 4. The results show clearly the linear relationship.

4. *Effect of Stone Size*

Four beds of calcite one foot in depth were prepared, each with a stone of different size. The average diameters employed were 4 mm., 2.5 mm., 1.4 mm. and 0.63 mm., all of each size being within close limits of the average. Waste diluted to a mineral acidity of 4,250 p.p.m. was passed through each bed and the rate of application adjusted until the pH of the effluent was 4.2, indicating complete neutralization of the mineral acidity. The rates recorded are plotted against the stone diameter and mesh size range in Fig. 5.

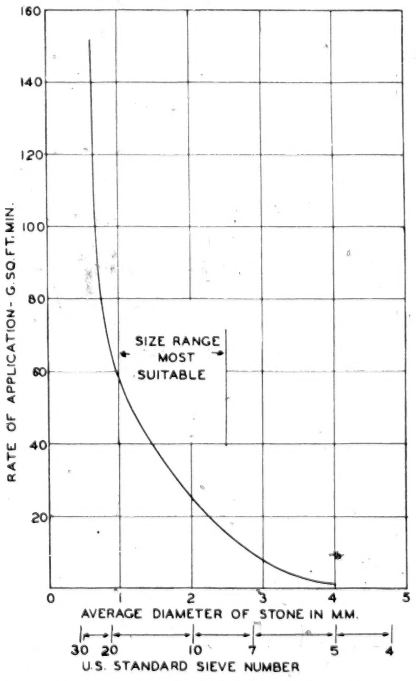

FIG. 5.—Affect of stone size on rate of application of nitro-cellulose waste to up-flow bed.

From the shape of this curve it is evident that the rate of application allowable to obtain neutralization is dependent upon the surface area of the stone. The rates of possible application increase rapidly as the stone size decreases. No effort was made to show this relationship

directly as more important practical factors would determine the stone size. Stones under 1 mm. in size tend to expand excessively at the high rates of application and, if too small, wash out with the effluent unless larger particles are present in predominating quantity. Stones greater than 2.5 mm. in diameter allow too low a rate of application as compared with those obtainable with smaller stone. From the practical standpoint stone passing ten mesh and caught on twenty yielded results most desirable from all standpoints. However, a wider range in particle size could undoubtedly be employed in plant scale operation if the percentage of large and small particles in relation to the average size were kept low. Stone in the range of 7- to 30-mesh should prove satisfactory.

After neutralization of the mineral acidity the pH is 4.2 as a result of dissolved CO_2 present. Most of the CO_2 can be removed and a subsequent higher pH obtained by a drop off a wier or by a short period of aeration. Samples having an initial pH of 4.2 after treatment by passage through the bed, were poured rapidly from one container to another three feet below it. The agitation, resulting in loss of CO_2, raised it to pH 6.0.

TABLE IV.—*Effect of Aeration on pH Values*

Aeration Time (min.)	Final pH	Alkalinity (p.p.m.)
0	4.3	5
1	6.8	–
2	7.2	–
3	7.4	–
5	7.8	–
10	8.0	7

Aeration of an effluent having a pH of 4.3, with diffused air, resulted in the changes in pH, alkalinity and acidity shown in Table IV.

The behavior of a one-foot bed of calcite of 10- to 20-mesh, on continuous rate application of a total of 8.5 gallons of waste having 4,230 p.p.m. mineral acidity, was observed and the pertinent data such as effluent pH, alkalinity, mineral acidity, and the depth of stone remaining at intervals was noted. A summary of the results is shown in Table V. Study of this table shows that at a set rate of application with a constant acidity, the bed depth can be adjusted to a depth where it is not a critical factor and additions of more stone could be made periodically on the basis of effluent pH. Thus operation of this process lends itself to ready control with a continuous pH meter for the regulation of time of delivery of new stone to the bed. With the rate of application and bed depth fixed to meet the maximum acidity of the waste discharged, this device could be developed to automatically produce an effluent between pH 4.2 and 4.5 continuously.

TREATMENT OF UNDILTED SULFURIC ACID AND NITRO-CELLULOSE WASTES

Because high rates of application were shown to be practical it was believed possible to treat undiluted waste by this method as the calcium

TABLE V.—*Treatment of Nitro-Cellulose Waste on Calcite Expansion Bed*

Gallons Treated	Minutes of Run	pH Effluent	Remaining Bed Depth (inches)	Mineral Acidity of Effluent (p.p.m.)	Alkalinity of Effluent (p.p.m.)
0.0	0	—	12.0	—	—
1.4	5	4.7	—	0	31
2.8	10	4.5	—	0	27
4.2	15	4.3	8.5	0	5
5.6	20	4.2	—	0	0
7.0	25	4.0	—	28	0
8.5	30	3.8	4.5	36	0

Acidity of Applied Waste—4,230 p.p.m. Mineral Acidity.
Rate of Application—40 g. per sq. ft. min.
Bed Depth—1 foot.
Calcite—10- to 20-mesh.

sulfate formed would be washed from the bed continuously. In some cases the discharge of large quantities of suspended calcium sulfate in the treated waste is not objectionable, and since control of this process is simpler than direct addition methods and the bed could be kept free of calcium sulfate deposits by high rates of flow, treatment of undiluted waste might be practical.

To determine the feasability of treating undiluted wastes, an expansion bed about two feet deep, containing stones of 2 to 3 mm. in diameter was used. Waste containing 8,500 p.p.m. mineral acidity present as sulfuric acid was applied at rates varying from 11.6 to 60 g. per sq. ft. per min. and pH, mineral acidity, and alkalinity determined on the effluents. The results presented in Table VI show that complete neutraliza-

TABLE VI.—*Effect of Undiluted Waste on Up-Flow Limestone Bed*

Rate of Application (g. per sq. ft. min.)	Time of Flow (min.)	pH of Effluent	Acidity of Effluent (p.p.m.)
20.4	5	4.2	0
8.8	10	1.8	650
88.0	10	1.2	8,000
12.8	10	1.2	7,000
After washing with 10 per cent HCl			
12.8	10	1.2	7,000

tion could be obtained under these conditions for a short period of time at a rate of application of 20.4 g. per sq. ft. per min. During this period a heavy residue of calcium sulfate was discharged from the bed and did not appear to accumulate. Despite the removal of the precipitate, the neutralizing action of the bed fell off suddenly and calcium sulfate ceased to form despite a gradual reduction in rate to 8.8 g. per sq. ft. per. min. Believing a coating of the stone was occurring despite its

clean appearance, the rate was increased to 88 g. per sq. ft. per min. to see if this high rate would wash the stone free of deposited residue. The rate was dropped to 12.8 g. per sq. ft. per min. and the pH and acidity again measured. Results show that the bed failed to return to anywhere near its original neutralizing capacity. Even washing the stone with an acid forming a soluble end product failed to restore or even improve the neutralizing capacity of bed.

Very similar results were obtained with nitro-cellulose waste having a mineral acidity of 12,400 p.p.m., 8,300 p.p.m. of which was due to sulfuric acid. It seems that wastes containing sulfuric acid must be diluted to a point where calcium sulfate does not precipitate out. A safe limit for acidity due to sulfuric acid is about 5,000 p.p.m., judging from results obtained in these experiments.

Other Acid Wastes

1. *Pickling Liquor*

A sample of pickling liquor from a continuous pickler was diluted with tap water to a mineral acidity of 2,400 p.p.m. This waste was applied to a one-foot up-flow bed of 10–20-mesh stone at varied rates. Results of this run are presented in Table VII, in which neutralization obtained at the various rates is compared with that obtained with a similar apparatus on nitro-cellulose waste. It is apparent from the lower rates at which neutralization was obtained with the pickling liquor that the iron sulfate present caused a reduction in the rate of reaction noted for mineral acids alone.

Table VII.—*Comparison of Neutralizing Capacity of Up-Flow Limestone Bed for Pickling Liquor and Nitro-Cellulose Waste*

Pickling Liquor Diluted to 2,400 p.p.m. Mineral Acidity			Nitro-Cellulose Waste Diluted to 2,150 p.p.m. Mineral Acidity		
Rate of Application of Waste (g. per sq. ft. min.)	pH of Effluent	Mineral Acidity of Effluent (p.p.m.)	Rate of Application of Waste (g. per sq. ft. min.)	pH of Effluent	Mineral Acidity of Effluent (p.p.m.)
14.0	4.1	10	72.0	4.2	0
22.5	3.5	130	88.0	3.1	46
31.2	3.0	200	99.0	2.9	70
37.0	2.5	660	110.0	2.4	145

Bed one-foot deep.
Calcite stone through 10-mesh caught on 20-mesh sieve.

2. *Single Mineral Acids*

Solutions of the three common mineral acids, HCl, H_2SO_4 and HNO_3 were made by adding technical acids to tap water to obtain concentrations within the range of 1,000 to 5,000 p.p.m. mineral acidity (as $CaCO_3$). Each of these were run through an up-flow bed of 10- to 20-mesh calcite stone 1 foot deep and the rate adjusted to the point where the effluent was free of mineral acidity or a pH of 4.2. Rate of flow was

recorded for each batch. A tabulation of the rates obtained for each concentration of each acid is presented in Table VIII. These figures show that the neutralizing capacity of the bed was the same for all three acids, as the rates observed for each concentration were the same within limits of experimental error.

TABLE VIII.—*Neutralizing Capacity of Up-Flow Limestone Bed for Single Dilute Mineral Acids*

Mineral Acidity (p.p.m.)	HCl	H_2SO_4	HNO_3
	Rate of Application (g. per sq. ft. min.)		
1,000	60	62	62
2,000	54	56	55
3,000	42	44	42
4,000	33	36	34
5,000	30	28	31

Bed one-foot deep.
Stone size 10- to 20-mesh.

3. *Acid Waste from Chemical Manufacture*

A waste consisting essentially of sulfuric acid and hydrochloric acids contaminated with a number of organic chemicals was diluted to various degrees and each dilution treated on a limestone bed one foot deep at rates capable of completely neutralizing the mineral acidity and at rates in excess of this. Plotted in Fig. 6 are the results of these runs. Examination of the curves reveal that the contaminating chemicals did not affect the neutralization appreciably as the rates at which neutralization was obtained are substantially the same as those observed in the treatment of mineral acid solutions recorded in Table VIII.

DISCUSSION

Difficulties experienced in neutralizing acid waste waters on limestone beds were overcome by an experimental unit employing a bed of fine stone in which the waste was applied at high up-flow rates, similar to the backwashing of sand filters. Dilution of wastes containing more than 5,000 p.p.m. of mineral acidity due to sulfuric acid was found necessary as concentrations in excess of this led to the precipitation of calcium sulfate. When this occurred, the neutralizing ability of the stone was to a great degree destroyed and even washing with strong mineral acids such as hydrochloric failed to restore its activity. The cause of this effect was not investigated further but is believed to be due to a coating of calcium sulfate on the stone despite the fact that no signs of it were noticeable and that hydrochloric or nitric acid treatment failed to remove it. Further investigation of this interesting phenomenon will be made.

Dilution of such waste prior to treatment is generally advantageous as sludge formation is eliminated entirely. Calcium sulfate formed in

the reaction between limestone and sulfuric acid appears to form a relatively stable supersaturated solution. As further dilution by almost immediate addition to a receiving body of water occurs in practice, long time stability is not necessary.

Amorphous and crystalline high calcium limestones were found to yield practically identical results under similar conditions of stone size and weight. It appeared that the type of stone adaptable for this

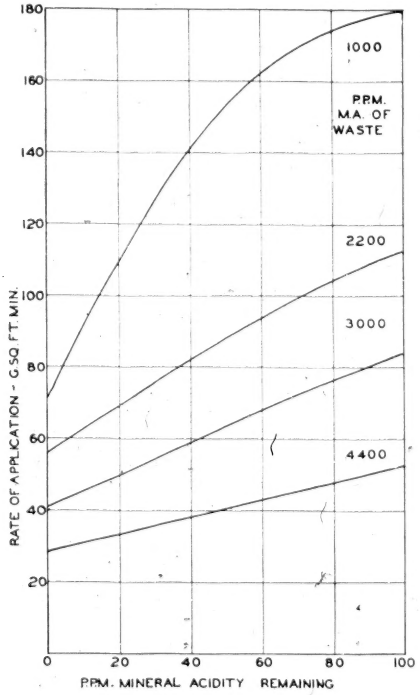

FIG. 6.—Neutralization of chemical manufacturing waste on up-flow limestone bed.

purpose is not specific and that any high-grade calcium limestone is satisfactory.

Wastes containing the three most common mineral acids and combinations of them react in a very similar manner in regard to upflow limestone bed requirements. Sulfuric acid concentrations, however, should not exceed 5,000 p.p.m. as under such conditions the bed becomes inactive when precipitation of calcium sulfate takes place in the bed. It occurs even when rates of application of waste to the bed are far in excess of that required to wash this residue free of the stone.

Wastes containing appreciable amounts of suspended solids would probably be difficult to treat by this process as fouling of the distribution system and bed might occur. It should prove most suitable for acid wash waters in which the acids are mineral and suspended matter is practically absent.

The size range of the limestone used depends to some degree on the rate of application employed. At rates around 100 gal. per sq. ft. per min., stone should be greater than 10 mesh as smaller sizes would be swept from the bed. For rates of 50 gal. per sq. ft. per minute, the smallest size allowable appears to be 30 mesh. These values were established on the basis of a small column and may not hold for a large bed. Although the particles are reduced in size due to reaction with the waste, loss does not appear to become serious as the depth of the bed is also reduced. The larger size stones added with recharges appear to hold the smaller ones in the bed when it is built up to original depth after a considerable run. Even small percentages of oversize stones must be avoided as they would gradually accumulate and make up a rather inefficient bed.

Initial uniformity within reasonable limits is also desirable from the standpoint of reaction, as the smaller the stone the greater the reactive area presented and the more efficient the bed. For practical operation employing average rates of application the limestone sold as "No. 2 chick gravel" should prove suitable, as this product runs between 8- and 30-mesh in size and is lower in cost than any other neutralizing agent with the exception of limestone flour.

The linear relationship which was shown to exist between bed depth, rate of application and acidity of wastes together with a knowledge of the requirements for successful operation allow ready computation of the combination best suited to the application of this process. The requirements are as follows:

1. Rates of application above 20 gal. per sq. ft. per minute and not in excess of 80 gal. per sq. ft. per minute. These limits are set by the necessity of washing gases and impurities of the limestone from the bed and holding the velocity below the point where the stone will wash out. The stone should be expanded throughout its entire depth.
2. Waste acidity not in excess of 5,000 p.p.m., sulfuric acid acidity.
3. Bed of reasonable depth (i.e. 2 to 4 ft.) so that expansion is not excessive, yet of sufficient depth that depletion of six inches or more is allowable due to decomposition of stone by the acid.

Thus, if it is required to treat a waste of about 5,000 p.p.m. at rates of application of 50 gal. per sq. ft. per minute, a three-foot bed is indicated. Under these conditions neutralization of mineral acidity will be complete until the bed depth loss is 6 inches at which point limestone make up would be necessary. At the start, the pH of the effluent would considerably exceed pH 4.2 and would gradually drop as the limestone was decomposed. Thus a simple automatic means of control through the use of a continuous pH indicator or recorder, activated by electrodes

immersed in the effluent, is possible. Signals on the instrument can be arranged to start and stop a flow of limestone delivered to the bed at any desired pH value. For example, the signals could be set to start the delivery of stone to the bed when a pH value of 4.2 was approached and stop when a pH value indicating that the bed was filled to a desired depth was reached.

The high rates of application of waste possible with the up-flow bed brings the size and hence the cost of the installation down very low; the equipment requirements being small. For example the treatment of 100,000 gal. of nitro-cellulose waste per day having a mineral acidity of 12,000 p.p.m. would require a bed three feet deep and only three square feet in area. A pump sufficient to discharge 160 gallons per minute at the required pressure, of waste diluted with 1.2 times its volume of water, will be required. Facilities for storing and feeding 5 tons of limestone per day and the necessary control instruments include all the main requirements.

Construction of the bed suggested is similar to that of a rapid sand filter with the exceptions that acid-proof materials be employed, more freeboard be allowed between the surface of the bed and the wash water troughs which will carry off the effluent, and that these troughs be of adequate capacity to carry the high flows handled. The latter requirements depend upon the rates of application to be employed. From observations made on bed expansion and stone carryover, using an initial size of 10- to 20-mesh stone, a freeboard of six feet should prove more than adequate for a bed three feet deep at rates in the neighborhood of 50 gal. per sq. ft. per minute.

Cylindrical tanks arranged for peripheral overflow should prove satisfactory for this purpose. Support and distribution systems of porous carborundum plates would be excellent for cases where suspended solids are absent in the waste or where they are very low in concentration or where such solids could be readily removed by rapid flow wire filters prior to application. The advantage gained with this type is that no gravel support is required for the limestone, and the overall depth of the device is reduced.

Experiments demonstrated that waste waters treated to pH values of 4.2 or higher are readily stripped of their CO_2 content. Short aeration periods, riffles, drops from wiers, or passage through contact aerators will rapidly remove practically all of this gas and raise the pH above 7.0.

In treating 100,000 gallons of the waste referred to above, over two tons of carbon dioxide would be produced per day. If a use was at hand for this gas it could be readily collected. Should the process be run in enclosures, means of exhausting the gas to the exterior of the enclosure should be provided.

From the data derived from the treatment of nitro-cellulose waste, it was possible to formulate equations for the calculation of the maximum rate of application possible to complete neutralization of a waste in beds of any depth for wastes of known mineral acidity. For stone

between 2 and 4 mm. in diameter and averaging 3 mm., the following equation applies for wastes having a mineral acidity of over 1,000 and not over 5,000 as sulfuric acid:

$$R = 35d\ [K\ (MA{-}1)]$$

R = Rate of application of waste in gal. per sq. ft. per min.
d = Depth of bed in feet
MA = Mineral acidity of waste in thousand p.p.m.
K = 6, for stone averaging 3 mm. in diameter

For stone between 1 and 2 mm. in diameter and averaging 1.5 mm. the following equation applies:

$$R = 66d\ [K\ (MA{-}1)]$$

The value K with stone of this size is 9.

These are not exact expressions but will serve as a basis for design. Constants undoubtedly bear a linear relationship to the total surface area of the stones per foot of depth but their calculation on this basis is not deemed necessary for the application of this principle to the neutralization of acid wastes. The formulae presented serve the purpose because size range is limited by operational factors.

No particular success in treating wastes containing acid salts, such as diluted pickling liquor was obtained by the up-flow limestone bed. Rates at which neutralization of the mineral acidity approached completion were only about 5 per cent of those possible for nitro-cellulose waste.

The three most common mineral acids, sulfuric, hydrochloric and nitric, when diluted to below 6,000 p.p.m. ($CaCO_3$) acidity, all responded alike to up-flow limestone bed treatment. At reduced rates, concentrations of hydrochloric and nitric acids higher than 6,000 p.p.m. could probably be treated. However, a concentration would probably be reached where too great a bed depth would be required to keep the rate sufficiently high to sweep the bed of gas and impurities and hold the stone in suspension.

Trials with a chemical waste containing sulfuric and hydrochloric acids together with many contaminating chemicals showed that such waste could be handled by the up-flow bed at rates equivalent to those obtained for uncontaminated acids.

Attempts to use such a process should be preceded by pilot scale tests to determine the effect of contaminants if present. The presence of considerable quantities of organic acids, oils, acid salts, and solvents might affect the process appreciably.

Conclusion

1. Acid wastes relatively free of solids can be continuously neutralized by up-flow application to beds of limestone gravel.

2. It was demonstrated that neutralization could be obtained at flow rates of from 20 to 100 gal. per sq. ft. per minute with rates of about

50 gal. per sq. ft. per minute yielding the most satisfactory results from several standpoints.

3. Both amorphous and crystalline high calcium limestone is suitable.

4. Relationship between acidity of waste, depth of bed and rate of application of waste are linear.

5. Equations were written to aid in determining the most suitable characteristics for a particular condition.

6. The stone size range found in No. 2 limestone chick gravel was shown to be most effective and is readily available.

7. Wastes containing sulfuric acid acidities in excess of 5,000 p.p.m. ($CaCO_3$) must be diluted prior to application to an up-flow bed.

8. Wastes containing appreciable concentration of acid salts, such as copperas, are not neutralized at the high rates observed for other acid wastes.

9. The common mineral acids respond very similarly to up-flow limestone bed treatment.

10. Experiments indicated that some contaminating chemicals do not effect this method of neutralization.

11. The up-flow limestone bed shows promise of providing neutralization with little supervision and control at a very low initial equipment cost.

Acknowledgment

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Stream Pollution

SEWAGE DISPOSAL PROSPECTS IN SOUTH AMERICA *

By Edward J. Cleary

Managing Editor, Engineering News-Record
New York, N. Y.

My great pleasure in being here today can be exceeded only by your misfortune in not having an opportunity to hear Prof. Gordon M. Fair, originally scheduled to appear at this luncheon.

When I conferred with him a few days ago, shortly after I returned to this country, I asked what he would want me to say to a group of this kind. The reply of this eminent Harvard educator was given with an air of complete finality, and it filled me with consternation—"Entertain them; they will have just enjoyed a satisfying lunch and will want to relax."

While I will not be so presumptious to believe that I could entertain you, I will endeavor to provide the opportunity for relaxation—soon the room will be darkened for the showing of slides.

Before so doing, however, I deem it an obligation to make a formal statement, the substance of which may be startling to many in this audience. Briefly stated, it is this:

There are no sewage disposal problems in South America. And furthermore, there never was, and there will not be in the immediate postwar period any appreciable market for sewage disposal engineering service or equipment.

If you feel properly startled, I'll go on to explain. First, I will amplify my statement about no sewage disposal problems. Like all generalizations, this is only partly true. Sewage disposal has come up for consideration in some places, but so far as presenting problems—the type of problems that you and I discuss in meetings of this kind and write articles about—they just don't exist on any scale in Latin America. In over 16,000 miles of travel during which I talked with scores of sanitary engineers, I didn't hear a single word about high rate filters versus activated sludge, or, for example, vacuum filtration versus sludge drying on sand beds.

I did hear some discussion on the merits of the concrete slab and riser privy versus the bored hole latrine. And occasionally someone would mention sewers. And once I heard about a septic tank—a Pan American Sanitary Bureau engineer told me that a tank 10 x 74 x 7 feet deep, pretty small you will admit, would handle all of the flow that emanates from the outfall sewers at Lima with a population of 600,000 people.

* Presented at the Fourth Annual Meeting, Federation of Sewage Works Associations, Chicago, Oct. 21, 1943.

Gentlemen, this may sound as if I am debunking sewage disposal prospects in South America. That's exactly what I am trying to do—to break down some widely held misconceptions held by this audience. The same misconceptions, if you please, that I had until a few months ago. In fact I had so many screwy notions about South America before I got there, that I was a veritable encyclopedia of misinformation.

A realistic appraisal of the situation—one that I have had opportunity to check with Latin American engineers in the various countries that I visited as well as against the observations of North American engineers like Gordon Fair, Major Harold B. Gotaas and others who have seen and studied the South American sanitation scene—leads me to these conclusions.

Basic sanitation needs—such as pure water supply facilities and the control of diseases like malaria—lay claim for first attention, and properly so.

You must picture South America as a vast continent whose overall development has reached the state about where the United States was in 1890. At that time, the records show, this country had very little in the way of water supplies such as we think of them today, we had a vast amount of work to do in the control and prevention of communicable diseases, and we weren't too much concerned about providing secondary treatment of sewage for our cities, let alone giving consideration to the needs of every town and hamlet. Even today, I learned from a recent survey, there are more than 3,000,000 people in the United States who lack even such elementary facilities as a privy, to say nothing of more elaborate sanitation facilities.

With the exception of a few of the larger cities in South America, there are relatively few installations of sewerage systems—to say nothing of treatment plants. In the small towns and villages, where by far the greatest aggregate of population now resides, major attention is being devoted to teaching the people to build and use privy and bored-hole latrines.

Even after people have been taught the use and advantages of a water closet—certainly the first step that must be taken before installation of sewerage systems can be considered—the answer must be found to the very practical question as to who is going to supply the water closets and the necessary plumbing to connect them with the sewer system.

Certainly people who earn but 35 to 50 cents a day are incapable of making the investment required for the purchase of a water closet.

The problem is one that we here in the States will not be entirely unfamiliar with. It is the problem of rural sanitation, which has occupied a big place in the thinking of our state sanitary engineers and the U. S. Public Health Service.

Therefore, when we think of sewage disposal prospects in South America, we must recognize the close kinship between the situation south of the border and that which exists in our rural areas. If you develop this viewpoint you can readily appreciate what I mean when I

say that I cannot share the enthusiasm of one school of thought in the United States who picture huge demands that will be made upon North American engineering service and equipment in the immediate postwar picture. Some day there may be a demand for American sewage disposal methods and equipment—say, ten or thirty years hence—but even if our stuff is the best, the prices of European equipment will also be a determining factor in what we can sell.

As for the prospects of North American engineering and consulting service being in demand, I likewise can voice little enthusiasm. In the first place, please be assured that there are a good many qualified and well trained sanitary engineers in Latin America, many of them nationals who have received graduate training either in the States or on the continent of Europe. Some of them told me that there is so little work, and such little prospect of immediate activity in sanitary engineering that they have found it necessary to occupy themselves in other branches of engineering. One case in point is that of a highly skilled sanitary engineer, a former student of Professor Fair at the Harvard Graduate Engineering School; he lives in one of the most progressive and active states in Brazil, yet he tells me that as consulting sanitary engineer to this state he can find only enough to keep him busy about two days a month. As a result, he has found it necessary to find other employment in addition to his consulting duties, and for that reason was serving as the manager of a chemical industry.

Another reason why I discredit the opportunities for consulting sanitary engineering service, so far as North Americans are concerned, is the fact that in most of the Latin American countries no engineer can practice without being licensed and registered. The requirements for such registration are quite rigid, including, among other things, the possession of a university degree from a university in the country in which you wish to practice.

I think you will find that in most cases where North American consulting firms are engaged in a Latin American country, they are doing so under the auspices of a special federal decree in which it is stipulated that they must have on their staffs a large number of nationals.

I would like to make it very clear at this point that none of my comments must be construed or were they intended to reflect on the advance of sanitation measures in South America. Great progress is being made, but first things must be considered first—and the installation of sewage disposal works can be considered only after other needs have been met. To those who may feel otherwise, it need only be recalled that in the United States activity in the field of sewage treatment has been a relatively recent development.

As I said earlier in my talk, one of the objectives of my message to this group is to break down some misconceptions. Therefore, I must reiterate, that with few exceptions, cities in South America are not ready for sewage treatment works nor will they be for some years to come. So much for what I am presumptuous enough to consider as the "educational" part of my talk. Now, I'll endeavor to furnish opportunity for relaxation by showing pictures that I took on my recent trip.

CONSERVATION AND SANITATION *

By Robert F. Legget

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"Conservation and Sanitation" may appear to some to be an unusual title for a paper at this meeting, even an unusual juxtaposition of terms. On the other hand, it has been suggested that any speaker addressing this gathering on the subject of conservation is merely "preaching to the converted" on the grounds that all interested in sanitation must necessarily be ardent proponents of conservation. Possibly somewhere in between these two extremes the truth will be found. Conservation and sanitation, far from being unrelated, are intimately associated and yet there may be some who have not fully realised this vital connection. It may be profitable, therefore, to review in general terms the significant correlations of the two, indicating how vitally important a part of general conservancy work sanitation must always be and, correspondingly, how work in the field of sanitation can be and should be assisted by an appreciation of the broader implications of conservation and of its social significance. It is not to be expected that such a discussion will reveal anything new but if it provides ground for argument, a useful purpose will have been served. "When all think alike," Walter Lippman has said, "no one thinks very much." Surely it will not be said that in such a gathering as this, nobody is thinking very much!

Conservation is a word that is slowly but surely coming into common use, as the ideas which it connotes become better appreciated and less misunderstood, in the public mind. It is a word which, in its common use, carries always the implication of its application to renewable natural resources. Its full meaning comprehends the wise and proper use of these resources coupled with their husbanding and protection so that they may continue thus to be wisely and properly used by generations yet unborn. The concept is a logical one, the soundness of which can not be disputed by any true citizen. And yet on this continent it is a relatively new idea, one that is still appreciated in full only by the few. President Theodore Roosevelt was one of the first to stress publicly the vital need and importance of conservation in North America. Through his efforts the National Conservation Commission was set up in the United States in 1909, and correspondingly the Canadian Commission of Conservation in the same year. Both of these agencies have long since disappeared, despite the good work they did, although their influence still persists. The Canadian Commission was sacrificed on the altar of politics in 1921; its full story must one day be told, a story that will shed interesting light on the changing social pattern of Canada in the early years of this century.

It was only in the last century that the widescale exploitation of the

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virgin prairies and mountains of this continent took place. Forests were plundered of their greatest trees; "the bush" was attacked and cleared to give farming land; wild-life was massacred on an unprecedented scale—all a part of what is known as the pioneer life which opened up a continent in a lifetime, an achievement never previously attempted, an achievement never to be witnessed again. Today, in this land that is still called new, the more unfortunate results of this exploitation are the problems which now demand the adoption of conservational practices. The lessons thus provided have been learned by other peoples long since. In Europe, in normal times, conservation is a part of the ordinary way of life and so is not discussed as something new. There may be seen forests that have been cut, and farms that have been cultivated for many hundreds of years and which are today in as good condition as ever they were. In Japan, difficult though it may be for some to acknowledge anything in that country as good in these tragic days, soil and water conservation have been actively practiced for at least sixty years; only by such means could so small a country support so large a population.

In North America, and specifically in Canada, a start has been made at the adoption of conservational practices. It is only a start. The inertia of public apathy, and the active opposition of some reactionary supporters of the concept of free and so uncontrolled enterprise have still to be overcome. Forests must be controlled so as to provide maximum yield consistent with continuous growth; farming practices must be so developed and improved that the ravages of soil erosion are impeded and repaired; fish and wild life must be cultivated and protected so as to yield continuously; water—of all resources the most important, and yet the least appreciated—must be recognized as a public trust, to be despoiled or dissipated by no man but guarded and preserved as a national treasure. And is not sanitation very closely concerned with such wise control and use of water?

Sanitation is, of course, concerned with far more than just this, important though water is in all sanitary work. Fundamentally, it is concerned with the safeguarding of public health. Incidental to this monumental task is the control and direction of water supplies, sewage disposal systems, swimming pools and public bathing facilities, the supervision of supplies of milk, meat and other foods, refuse collection and disposal, the control of insect and animal nuisances, and of standards of housing and housing equipment.

In its fullest sense, sanitation is concerned with the conservation of the greatest of all natural resources—man. Dr. A. E. Berry, in a notable address delivered before the Toronto Branch of the Engineering Institute of Canada, now two years ago, paid eloquent tribute to this feature of sanitary work. He showed something of the great advances made in public health in recent years and of the contributions of the sanitary engineer to this achievement. Important though this subject is, it must be passed over today in favour of the more restricted connection between sanitation and the conservation of renewable natural re-

sources. Water is clearly the resource with which the sanitary engineer is primarily concerned but some attention must also be given to the disposal of solid refuse or garbage if the responsibilities of those in sanitary work in conserving natural resources are to be adequately discussed.

What should be, what must be the underlying philosophy of all such work? In this great country, a population of about eleven million people now lives in what is not, strictly speaking, a natural manner. Congregated very largely in urban centres of population, some of great size, the majority of Canadians are dependent upon public services for those features of living which their fellow-Canadians, who are still farm-dwellers, do for themselves. All, city and country dwellers alike, are dependent ultimately upon the continued productivity of the land, its forests and its waters. The role of sanitation would therefore appear to be the attainment of the highest practicable standard of public health and sanitary services for the maximum possible number of people while ensuring that the works necessary to achieve these results do not despoil any feature of the land that is Canada. Upon the works of the sanitary engineer, this paper can make no adequate comment. None is needed, for the high standard of sanitary engineering in Canada is well known. But do these works never despoil the landscape, nor pollute otherwise valuable resources?

Perhaps before attempting an answer, the oft-quoted saying "We should give the country back to the Indians" may be mentioned once again, mentioned only that it may be asked how many who voice this plaintive plea on cold winter days ever stop to think what it would be that *could* now be given to the Indian. Assuredly not the country that was won from him by the pioneers. In some artificial respects improved, perhaps; but in respect to its forests, its wild-life, its streams and lakes a very different land from that of even one hundred years ago. And the sanitary engineer and public official responsible for sanitary work must admit to some share of responsibility for the change, if only because of things left undone which ought to have been done.

Consider first, public water supply. This topic does not usually come within the purview of this body and so it will be but briefly mentioned. Many municipalities obtain their supplies from lakes and rivers but others have to rely on Nature's underground reservoir which they tap by means of springs or wells. How many give thought to the inter-relation of the water they thus use and its dependence upon the maintenance of proper vegetable and forest growth in the surrounding region. Some do, the rehabilitation of the springs supplying the Village of Beeton providing an outstanding example; but far too many do not. How many realise that Canada has no organisation, federal or provincial, which is concerned with the observation or control of the ground water of the Dominion, without which life would not be possible? Few indeed, and yet such vital work could easily and properly be done by the Geological Survey of Canada if only it were so empowered.

This Institute is more immediately concerned with what happens to water supplied for domestic and industrial use after it has been used. In Canada there are today about 1,300 municipalities that provide a public water supply. There are only 500 municipalities that have a public sewerage system. And there are only 115 municipalities that operate a sewage treatment plant of any kind. These figures will be familiar to you but will you consider anew their significance—for they are significant indeed. Compare the first two; they mean that in 800 municipalities water is supplied for public use with no provision for its removal through a sewerage system. The results of such private disposal of waste waters can better be imagined than described. It needs no argument to persuade such a body as this that the situation depicted by these figures is one that *must* be remedied as quickly as possible if only in the interests of public health alone.

It is the comparison between the second and third figures, however, that is of special importance in connection with conservation. There are, in Canada, 385 municipalities which provide a public supply of water, collect the waste water after use and then discharge it from a sewerage system without treatment of any kind. And the result? In all too many cases the fouling of streams, of rivers, of lakes, of the waters for which Canada is justly so famous, of water that might otherwise be used for a variety of useful purposes. You will be familiar with local results—the despoiling of lake and river beaches, the contaminating of even Lake Ontario water in some places so that even swimming has to be forbidden to those who badly need the relaxation it gives; the ruining of supplies of good drinking water so that even in "Old Ontario" a glass of cold water has sometimes to be apologetically described as "a glass of chlorine with a dash of water in it."

In this thing too, jesting is akin to tragedy. And yet there are those who can defend such dumping of untreated sewage into running or lake waters on the ground that it is no concern of theirs, that what happens to their wastes is something for which they bear no responsibility. There may even be some who would defend the discharge of foul wastes into the mighty St. Clair River, from both sides of the border, be it noted, turning parts of that lovely stream in places into an evil-smelling oily open sewer. This is but an example, chosen at random; there are, unfortunately, many others that could similarly be cited.

And of them all it can be asked—Do those responsible really think that the water they obtain for use is their private property, to be used as they will and then discarded, irrespective of its effect on others? There can only be one answer, a resounding—No, not so, the water you use is yours on trust, a part of one of the nation's invaluable resources, to be used assuredly, but to be conserved for the use of others and so returned to its natural course in its original condition or as close to this as is practicable.

It will be urged that in some cases at least untreated sewage can be safely discharged into water courses if the flow is such that natural aeration is sufficient to purify the water before the water has again to be

used. It is a big "if" as those resident in the Grand River Valley know full well. The Grand River, draining one of Ontario's most fertile valleys, was once a full flowing river, flooding in spring admittedly but so regulated by Nature that it flowed steadily throughout summer months. So did it flow within living memory but cultivation extended, trees were cut down, fields were plowed up and down hill, and as the crowning folly of all, the Luther Marsh was drained. Naturally the river dried up in summer, removing the once-natural means of waste water disposal down the valley. Eventually there was formed, as all here will know, the Grand River Conservation Commission, a union of the affected municipalities which has already spent almost two million dollars on the construction of the Shand Dam as a regulating structure. Useful as that structure is, it is only a beginning of the necessary remedial works. Conservation of that fine valley will not even be properly started until the Commission, or some other body, see that farm woodlots are replenished and protected, poor farming areas are reforested, farming practices brought up to date with contour plowing the universal practice on all sloping ground, and the Luther Marsh put back again into its natural condition. Only by such coordinated conservation of all resources in the valley the river, the land, the forest—can the Grand River again be made worthy of its name.

The fact that such measures are necessary in a valley that was settled only a hundred years ago is surely one of the most tragic commentaries possible upon the way in which Canada has allowed her resources to be abused. Recrimination at the past will avail but little; of infinitely greater importance is the fact that a start has been made at the necessary conservancy measures, and made (let it be hoped) before it is too late. It is understood that similar measures are now being planned for the Thames River Valley; the same may be true of other areas since there are all too many rivers calling for similar measures. In all these cases, the prime object of the conservancy work must be to provide a certain minimum flow in summer months, as will be well known to this gathering even though it be misunderstood in the public mind. Control of floods is an incidental benefit but the necessary emphasis upon regulation of flow makes a combination of all the conservancy measures mentioned absolutely essential.

It is, accordingly, singularly unfortunate that the name already made public for the regional board in the Thames River Valley is the "Thames Valley Flood Control Project Commission." It is greatly to be hoped that this title, as unfortunate as it is dissonant, is but a temporary label and that eventually there may be recognized a Thames Valley (or River) Conservation Commission. Such River Boards are already a feature of social organisation in older countries; they constitute the most logical means of undertaking conservancy work, conforming to natural rather than political boundaries. Every major river valley in the developed part of Canada needs a conservation body of this type; the lead given by the municipalities of the Grand River Valley may therefore prove to be one of unusual social significance.

If measures such as have been described and suggested have to be undertaken and at such cost, for the conservation of water, is not this a further reason for insistence upon the proper treatment of all waste waters (other than those that will be naturally purified in an adequate manner) before their ultimate discharge? So it would appear, and yet it will be urged that sewage treatment costs money and taxpayers are already too heavily burdened to pay for such "luxuries." Luxuries? Is public health a luxury? Is safe drinking water a luxury? Can the proper treatment of a national treasure held on trust be justly called a luxury? Never. If citizens want a public water supply, they must recognize—and be helped to recognize—that they must pay for the service not only of bringing water to them, but of taking the water away, and returning it fit for use by others. It is unfortunate, in this respect, that water supply and sewage treatment have become separated in the public mind; in some way, they must be reunited.

Visions of parsimonious aldermen striving to save a fraction of a mil off the tax rate, always with an eye to the future, will probably make some smile indulgently at these naive suggestions of one who is spared the complexities of municipal administration. To all such may frank admission be made that the immediate problems of the municipal engineer are appreciated, at least in part, by the speaker. Many necessary sanitary works can, however, be carried out at relatively small cost, small cost certainly when compared with expenditures upon other public facilities, and small cost indeed when considered in relation to value obtained. It may perhaps be suggested that many such works can most efficiently be carried out if based upon regional planning rather than unit planning. In this way costs can often be reduced and better service obtained than from small local units. The speaker hesitates to be specific on this point but he would urge all interested to study the matter further through the medium of an excellent book, "The Small Community," by Dr. A. E. Morgan. Regional planning needs cooperation. To achieve any of the results herein suggested will therefore call for an awakened social conscience, a better informed electorate, and a more truly democratic municipal franchise. The engineering profession should be in the lead in thus developing good citizenship, and a broad view of the inter-relation of conservation and sanitation is essential to the success of all such social pioneering. Admittedly the difficulties are great but so also is the problem, that of pure water despoiled and left untreated. A start must be made and made quickly or else in all too many cases old Thomas Carlyle's words will again be true "Unless something is done soon, something will do itself, and not very pleasantly."

A few words must be added about a detail of sanitation that does affect conservation, the conservation of natural beauty, the correction of which involves no extra expenditures. Reference is made to garbage disposal, admittedly an unattractive subject and yet an important one, very frequently neglected. How often does one see what has once been a sylvan glade now converted into a paper-strewn, rat-infested, dis-

graceful looking and noisesome town dump. Beauty unspoiled is impossible, of course, when garbage has to be disposed of, but by the adoption of modern sanitary dumping and land-fill practices, always working with the minimum length of open face, very great improvements can be effected, and at no extra cost, possibly at some increase in efficiency. If all municipal officials, particularly the town engineers, would regularly visit their garbage disposal areas there would inevitably be more converts to the cause of conservation than this paper can ever hope to win!

If you have agreed with the general thesis of this paper, some may now be thinking "Yes, we agree with that general picture, but what can we do?" Here, in conclusion, are some specific suggestions, their brevity suggesting a dogmatism that is not intended save only in so far as the need for some action is concerned:

(1) Realise that Canada's natural resources are *not* limitless, that they have been abused, that if Canada is to have the future that should be hers, *they must be conserved;*

(2) Appreciate, if necessary after further study, that all renewable natural resources are inter-related; if one resource—be it soil, forest, wild-life or water—be interfered with, all the others will be affected;

(3) In all your thinking about your own special problems, consider water in its proper light—as the most valuable of all resources, to be used and conserved as a priceless national treasure;

(4) Remember that the waters of any one river valley, be it large or small, are the waters of one of Nature's own sub-divisions, river valleys (or catchment areas) being the only unit areas for which water conservation can properly be considered;

(5) In all your thinking and planning for your own communities, will you relate your special problems to the general picture of the national natural resources and keep in mind the fact that the water you use came from elsewhere and is passed on for the eventual use of others—as such, it is in your trust;

(6) In the preparation of your plans for post-war works, will you do all you can to see that necessary sanitary works get the priority that should be theirs—not alone as useful works, not only for the improvement of public health, but also because they are so vital a component in the conservation of the national resources;

(7) And lastly, as informed citizens of Canada, will you see to it that you never countenance glib talk in your presence about "Canada's boundless resources" (as though they were just waiting to be plundered still further) but rather will you do all that is in your power to correct such loose thinking, looking and working towards the day when Canadians, one and all, are militant advocates of conservation, mindful of the tremendous responsibility that possession of those vast resources that still are Canada's necessarily involves.

It is hoped that good grounds for discussion have now been presented. Were it not for a desire to keep discussion clear of all irrelevant questions, this paper might now stop. One thing more must

be added, however, since it relates to a question probably even now in the minds of some listeners. Much of what has been said has been, by implication at least, critical of Canadian municipal development; is it not somewhat invidious for one who is, at best, only an adopted Canadian thus to criticize the country that is now his? May some words of J. B. Priestley be used in answer? These words—"We should behave towards our country as women behave toward the men they love. A loving wife will do everything for her husband except stop criticizing him and trying to improve him. We should cast the same affectionate but sharp glance at our country. We should love it but also insist upon telling it all its faults. The noisy empty 'patriot,' not the critic, is the dangerous citizen." It is in this spirit, because he has been privileged to see so much of Canada and because he ventures now to call himself a Canadian that the speaker presents the thoughts embodied in this paper.

That the present is no bad time for the presentation of such views is perhaps indicated by the action of your Executive in asking that this paper be given. Looking ahead in certain confidence as to the eventual outcome of the war, it appears to be generally recognized as the bounden duty of all Canadians here at home that they should think about, discuss and prepare to plan the Canada that yet may be in that happy time now described as "after the war." As a part of post-war reconstruction, conservation of natural resources must loom large; as a part of post-war public works, sanitary engineering undertakings must inevitably assume an important place. If the latter can be planned and prosecuted against the background provided by broad appreciation of the necessary conservation of natural resources, then indeed will progress be made towards a Canada worthy of those who have yet to return. What should be done is known, although perhaps by the few; it must come to be known by the many. What has yet to be unlocked is the will to get things done:

"Knowledge we ask not—knowledge Thou has lent,
But, Lord, the will—there lies our bitter need.
Give us to build above the deep intent,
The deed, the deed."

RELATION BETWEEN STREAM FLOW AND QUANTITIES OF NITRATES *

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Nitrates are found in clean and polluted streams. The fact that certain micro-organisms produce nitrates under favorable conditions in surface waters and that nitrates are found in the effluents produced by certain biological sewage treatment processes has led to attempts to correlate the quantities of nitrates found in surface waters with the degree of pollution and the rate of recovery of streams. In some instances it appeared that the amounts of nitrates present were related to gross pollution or recovery, whereas in other cases no satisfactory relationships were found. If the quantities of nitrates found in streams were primarily the result of biological action on the polluting material present, the quantities to be expected should be higher during summer than winter. Similarly, the total amounts of nitrates should be relatively constant in a stream receiving a definite quantity of sewage pollution and the quantities expected should be materially higher in a polluted stream in the process of recovery than in a clean stream receiving no polluting matter.

In the course of studies pertaining to the degree of pollution and the recovery of several streams, a mass of analytical data was collected, part of which has been analyzed for the evaluation of the various factors involved. Particular attention was paid to the degree of pollution, type of stream, character of water, volume of water, temperature of the water and the catchment areas. For discussion in this paper, the results obtained have been limited to the Raritan River and its tributaries.

Drainage Area

The drainage areas of the Raritan and tributaries under consideration are as follows:

South Branch	277 square miles
North Branch	192 square miles
Raritan	490 square miles
Millstone	300 square miles

The river flow discharges used in the calculations of the results were supplied by O. W. Hartwell, District Engineer, U. S. Geological Survey.

Surveys

Pollution surveys were conducted during the years 1927–28, 1937–38, 1940–41 and 1942. The degree of pollution in the Raritan and

* Journal series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Water and Sewage Research.

tributaries has varied through the years. During the first survey practically none of the sewage from over 150,000 people reaching the Raritan was treated, nor were any of the industrial wastes, before discharge. In 1937–38 practically all sewage was treated, but very little of the estimated 20 m.g.d. industrial wastes. During 1940–41 all sewage and the bulk of wastes were treated before discharge. The North and South Branch receive very little domestic or industrial pollution, while all sewage discharged into the Millstone has been treated to a high degree since before the 1937–38 survey. The quantities of treated sewage discharged into the Millstone is less than 10 per cent of that discharged into the Raritan, and the industrial wastes amount to only a fraction of one per cent.

Results

The average daily flow and nitrates present in the Raritan and its tributaries, calculated on the results obtained during sampling days for the three surveys are given in Table 1. The yearly averages in flow

Table 1.—*Average Daily Flow and Nitrates in Raritan and Millstone Rivers*

	Flow (c.f.s.)			Nitrates (lbs.)		
	Summer	Winter	Yearly	Summer	Winter	Yearly
Raritan						
1927–28	607	797	679	1,907	5,748	3,401
1937–38	252	560	407	413	2,500	1,456
1940–41	98	637	401	221	2,607	1,366
Millstone						
1927–28	241	368	291	985	2,132	1,444
1937–38	282	181	231	384	1,340	862
1940–41	138	343	236	389	1,305	823
Raritan and Tributaries						
1927–28	848	1,410	1,066	3,527	8,479	5,923
1937–38	472	763	643	1,043	3,249	2,331
1940–41	255	1,020	586	607	3,765	2,105

for the different surveys show material variations, but less than the variations in the total quantities of nitrates present. The yearly averages in nitrates appear to have decreased gradually; however, the average flows follow the same trend. The differences in flow as well as the total nitrates in winter and summer are far more significant than the yearly differences. It is clear that the quantities of nitrates present in the stream during the winter far exceed the amounts present in the stream during the summer. In order to obtain a clearer picture of the average yearly and summer and winter quantities of nitrates in definite units of water and to show the differences between the various surveys, the results were recalculated in pounds of nitrates a day for 100 c.f.s. of flow (Table 2). The average yearly results over the three

TABLE 2.—*Average Pounds of Nitrates Daily per 100 c.f.s.*

	Yearly	Summer	Winter
Raritan			
1927–28	500	312	717
1937–38	312	163	446
1940–41	340	225	409
Millstone			
1927–28	489	408	579
1937–38	373	136	736
1940–41	349	282	380
Raritan and Tributaries			
1927–28	596	416	568
1937–38	426	221	361
1940–41	369	238	354

surveys still seem to show a gradual decrease in the total quantities of nitrates, which may be attributed to the decrease in gross pollution, but the results for winter and summer averages are not constant.

If the reduction in nitrates were caused by less pollution, the yearly average quantities of nitrates should be reduced in accordance with the average reduction of flow. Taking the 1927–1928 flows and amounts of nitrates, as a basis and comparing the percentage reduction in flow and nitrates for the different streams in 1941, we find the following:

	Flow Per Cent Reduction	Nitrates Per Cent Reduction
Raritan	41	60
Millstone	19	43
Raritan and Tributaries	45	65

The percentages reduction in flow are not the same as the percentages reduction in nitrates; moreover, the percentage reductions are not constant. It would be rather difficult to deduce from these figures that the total nitrates present might be correlated with pollution. The differences between the percentages varying from 10 per cent greater reduction to 7 per cent less are probably the result of experimental errors; especially if it is considered that the quantities of nitrates found per 100 c.f.s. during the winter were in all cases materially greater than those recorded for the summer periods. If nitrification of the pollutional matter entering the stream was an important factor the quantities of nitrates found during the summer would be expected to be higher than during the winter. This does not mean that pollution has no effect on the quantities of nitrates found, but shows it to be a minor factor. In this respect it may be pointed out that the quantities of ammonia found in the streams were about the same as the total amounts of nitrates, large enough to allow nitrification, and were not a limiting factor in the nitrification processes.

Other evidence that pollution plays only a minor role in the presence of nitrates even in a heavily polluted stream, is shown by a comparison

of the average nitrates found during the summer in the Raritan (1927–28) with the amounts of nitrates found during the same period in the North and South Branches, which received only a small fraction of the

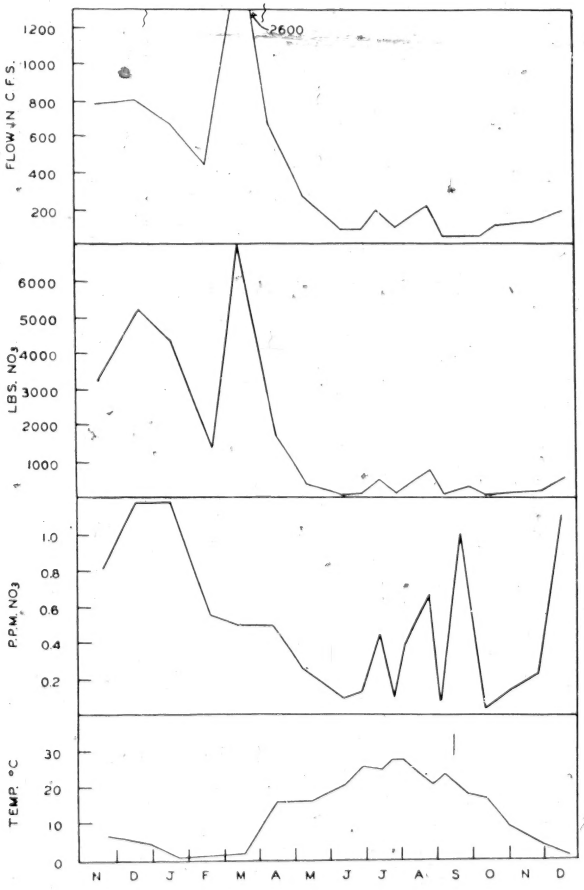


FIG. 1.—Correlations between flow, amounts of nitrates and temperature, Raritan River, 1940–41.

pollution of the Raritan. Calculating the pounds of nitrates per 100 c.f.s., we found:

Raritan	312 lbs. per 100 c.f.s.
South Branch	463 lbs. per 100 c.f.s.
North Branch	355 lbs. per 100 c.f.s.

The weighted averages for the 3 surveys made of the Raritan and its tributaries may be used to emphasize the difference between flow and nitrates during summer and winter (Table 3). The average flows

TABLE 3.—*Weighted Average Daily Flows and Nitrates for 3 Surveys, Raritan and Tributaries*

	Summer	Winter	Yearly
Flow (c.f.s.)	508	1,175	794
Nitrates (lbs. per day)	1,789	5,927	3,767
Nitrates (lbs. per day per 100 c.f.s.)	392	505	474

during the winter periods were about 230 per cent greater than during the summer periods, whereas the average pounds of nitrates a day during the winter periods were about 300 per cent greater. Clearly, with increasing flows the nitrates in the streams increased at an equal or greater rate.

Correlation between the actual flow and the amounts of nitrates found during 1940–41 in the Raritan is illustrated in Fig. 1. Obviously, there is no relation between the flow and p.p.m. nitrates present, but a close relation between flow and actual amounts of nitrates. For comparison, the temperature of the water at the times when samples were taken are also plotted. The quantities of nitrates were low at the higher temperatures and high during the winter months.

Since the quantities of nitrates vary with the flow in the stream or run off, an attempt was made to determine how closely the quantities of nitrates were related to rainfall. Samples taken before, during and after rains in summer time, were analyzed and the results are shown in Table 4 and Fig. 2. Rather widespread rains causing an appreciable increase in stream flow resulted in a rapid rise in the amounts of nitrates present, but even local rains which caused rather small increases in stream flow resulted in appreciable increases in nitrates (see

TABLE 4.—*Relation Between Stream Flow and Nitrates—Samples Taken Before and After Rains (1942)*

Date	Flow (c.f.s.)	NO_3 per Day (lbs.)	NO_3 per Day per 100 c.f.s. (lbs.)	Remarks
June 11	133	72	54	
13	284	153	54	
15	392	294	75	Rain June 14, river muddy
17	174	375	256	Rain 16, 17, river higher
22	174	234	131	River slightly muddy
25	178	288	161	
26	136	146	107	Local rain
27	133	86	65	Local rain
30	122	65	53	
July 3	392	211	72	Rain July 2
6	203	185	91	
20	214	345	161	
Aug. 21	1,550	4,169	269	Rains Aug. 9–19

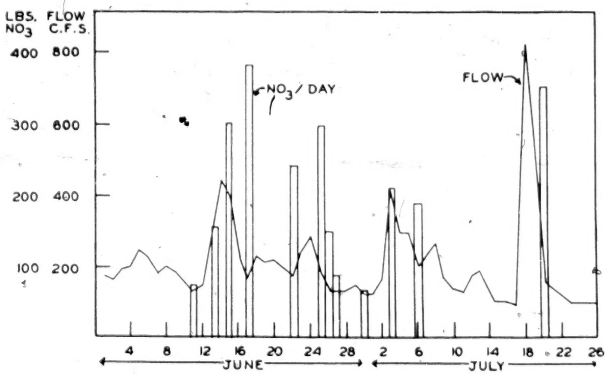


FIG. 2.—Relation between rainfall and nitrates.

June 15–16 and 26–27). When the river flow increased about 10 times after several days of rain, the quantity of nitrates increased 10 times or more (Aug. 21).

The question arises whether the relationship between flow of the stream and nitrates present is constant. Fluctuations of such a relationship in a given stream can be expected from the results presented. Calculations for the Raritan River System have been plotted tentatively (Fig. 3). The results, embodying many variables, are of considerable

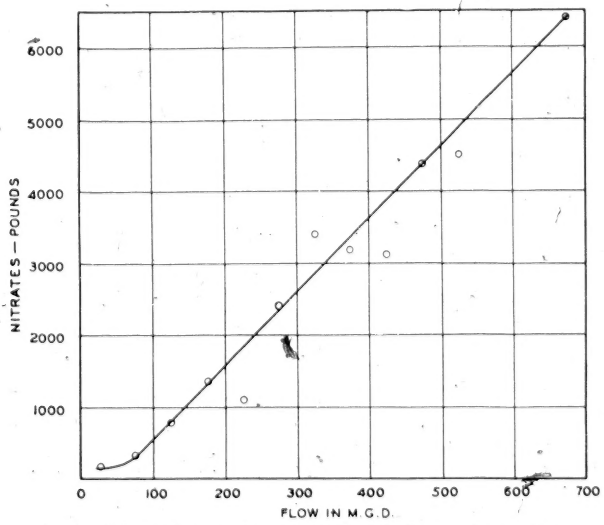


FIG. 3.—Relation between flow and nitrates for Raritan River system obtained during three surveys.

interest because of the apparent close relationship between flow in millions of gallons and the total pounds of nitrates per day found in the stream. No doubt, with still more results available for averages of each 50 m.g.d. increment, the slope of the curve may change somewhat, but the definite relation appears to be established.

The relation between stream flow and quantities of nitrates as far as the ratio between the two is concerned, is affected by a variety of factors. The most important factor appears to be the character of the drainage area (cultivated land, wooded, hilly, geological formation, etc.). The importance of the findings to agricultural scientists, who have been studying loss of fertility in lysimeter experiments over many years is apparent. This question, however, will be discussed separately in the near future.

Summary

Previous attempts to correlate the quantities of nitrates found in surface waters with the degree of pollution have failed. The presence of nitrates in surface water is of interest to those concerned with stream pollution and to those engaged in agricultural science. Results obtained on polluted streams over a period of years have been analyzed, showing that the quantities of nitrates present are not dependent upon the degree of pollution, that the temperature of the water is of minor importance, that the quantities of nitrates are materially higher in winter than in summer, and that the quantities of nitrates can be correlated with the volume of water in the stream. The character of the drainage area affects the amounts of nitrates present.

THE OPERATOR'S CORNER

OPERATOR'S QUALIFICATIONS

The report of the Federation's Committee on Qualifications of Sewage Treatment Plant Operators, published in the November issue of the *Journal*, is well worth the most careful scrutiny of every sewage works operator. Under the leadership of Chairman L. W. Van Kleeck of the Connecticut State Department of Health, the Committee has made a real contribution in the thorough analysis of the aims and basic policies concerning certification of operators, the schedule of qualifications for the various grades of operators, the recommendations for special training and the suggested details of the administration of certification plans, all of which are contained in this comprehensive report. The Committee is due a unanimous vote of thanks for its fine work.

Realizing the importance of the report, the Board of Control has provided opportunity for everyone concerned to express his views on the policies and detailed procedures which are recommended. Publication of the report in the last issue of the *Journal*, with an invitation for written comment and criticism, and arrangement for oral discussion of the matter during the 1944 Annual Meeting of the Federation, were ordered by the Board.

It is the writer's opinion that the report is in good balance between the three interests most vitally concerned, i.e., plant operation personnel, the municipality and the state agency responsible for stream pollution control, including supervision of sewage works operation. Nevertheless, some factors may have been overlooked and it is only logical that popular approval be sought prior to the adoption of a principle which will assuredly influence all existing and future operator's certification programs.

The Committee desires your assistance. Constructive criticism is welcome!

W. H. W.

REVISED ORDER P–141

(As Amended January 5, 1944)

PART 3287—GOVERNMENT SERVICES [1]

[Preference Rating Order P–141, as Amended Jan. 5, 1944]

PUBLIC SANITARY SEWERAGE FACILITIES—MAINTENANCE, REPAIR AND OPERATING SUPPLIES

§ 3287.26 [1] *Preference Rating Order P–141*—(a) *Definitions.* For the purpose of this order:

(1) "Operator" means any individual, partnership, association, corporation, governmental corporation or agency, or any organized group of persons, whether incorporated or not, located in the United States, its territories, or possessions, engaged in or constructing facilities for the purpose of engaging in, the operation of a public sanitary sewerage system or a public sanitary sewerage system combined with a storm sewerage system, whether or not such operator has applied the preference ratings herein assigned.

(2) "Controlled material" means steel—both carbon (including wrought iron) and alloy—copper (including copper base alloys) and aluminum, in each case only in the forms and shapes indicated in Schedule I of CMP Regulation No. 1.

(3) "Material" means any commodity, equipment, accessory, part, assembly or product of any kind.

(4) "Maintenance" means the minimum upkeep necessary to continue an operator's property and equipment in sound working condition.

(5) "Repair" means the restoration of an operator's property and equipment to sound working condition after wear and tear, damage, destruction of parts or the like, have made such property or equipment unfit or unsafe for service.

(6) "Operating supplies" means:

(i) Material which is essential to the operation of the system specified in paragraph (a) (1) and which is generally charged to operating expense account.

(ii) Material for an addition to or an expansion of sewerage system or works, other than buildings, provided that such an addition or expansion shall not include any work order, job, or project, in which the cost of material shall exceed $1,500 in the case of underground sewer or pipeline addition or extension, and $500 in the case of any other addition or expansion and provided that no single construction project shall be subdivided into parts in order to come below these limits.

(7) Material for "maintenance," "repair" and "operating supplies" includes any material which is essential to minimum service standards, and does not include material for the improvement of an op-

[1] Formerly Part 3209, § 3209.1.

erator's property or equipment through the replacement of material which is still usable.

(8) "Supplier" means any person with whom a purchase order or contract has been placed for delivery of material to an operator, or to another supplier.

(9) "Calendar quarterly period" means the several three months of the year commencing January 1, April 1, July 1, and October 1, or the operator's customary accounting period closest to such period.

(10) "Inventory" means all new or salvaged material in the operator's possession, unless physically incorporated in plant, without regard to its accounting classification, excluding, however, material which is segregated for use in additions and expansions specifically authorized under paragraph (g) (2) of this order or by an operative preference rating order or certificate issued by the War Production Board.

(b) *Preference ratings.* A preference rating of AA-1 is hereby assigned to orders to be placed by an operator for material to be used for maintenance or repair, and for operating supplies.

NOTE: Paragraph (2) deleted Jan. 5, 1944.

(c) *Controlled materials*—(1) *Steel and copper.* Subject to the quantity restrictions contained in paragraph (f) of this order, any operator requiring delivery of any controlled material, except aluminum, for maintenance, repair or operating supplies, may obtain the same by placing on his delivery order the certification required in paragraph (c) (1) (i) hereof. An order bearing such certification shall constitute an authorized controlled material order.

(2) *Aluminum.* (i) Any operator requiring aluminum in any of the forms or shapes constituting a controlled material, for essential maintenance, repair or operating supplies, where the use of other materials for the purpose is impracticable, may obtain the same from a controlled materials producer or from a distributor specifically authorized by the War Production Board to engage in the business of receiving aluminum for sale or resale, in an amount not to exceed 100 pounds from all sources during any one calendar quarterly period by placing on his delivery order the certification required in paragraph (c) (1) (i) hereof. An order bearing such certification shall constitute an authorized controlled material order.

(ii) Any operator who requires aluminum in any of the forms or shapes constituting a controlled material, in amounts aggregating more than 100 pounds from all sources during any one calendar quarterly period for use as essential maintenance, repair or operating supplies where the use of other material for such purpose is not practicable, may apply for an allotment of the amount thereof in excess of 100 pounds during any one calendar quarterly period by letter addressed to the Aluminum and Magnesium Division, War Production Board, Washington, D. C., Ref: P-141. The letter should contain substantially the information called for by paragraphs (d) (1) to (6) of Supple-

mentary Order M–1–i, as amended March 10, 1943. If the application is granted, the applicant will receive an allotment number or symbol and may place an authorized controlled material order by endorsing an order with such allotment number or symbol and the certification prescribed in paragraph (e) (1) (i) hereof.

(d) *Restrictions on use of symbol and ratings.* (1) The allotment symbol and preference ratings hereby assigned shall not be used by an operator or supplier to obtain deliveries of scarce material, the use of which could be eliminated without serious loss of efficiency by substitution of less scarce material or by change of design.

(2) The preference ratings assigned by paragraph (b) (1) hereof for maintenance, repair and operating supplies shall not be used to obtain any item included in Lists A or B of Priorities Regulation No. 3.

(e) *Application and extension of ratings; application of CMP allotment symbol*—(1) *Certification.* The AA–1 rating assigned by paragraph (b) of this order and the CMP allotment symbol MRO–P–141 may be applied by an operator to deliveries of material for use in maintenance, or repair, or as operating supplies only by use of a certification in substantially the following form:

> Preference Rating AA–1, CMP Allotment Symbol MRO–P–141. The undersigned purchaser certifies, subject to the penalties of Section 35 (A) of the United States Criminal Code, to the seller and to the War Production Board, that to the best of his knowledge and belief the undersigned is authorized under applicable War Production Board regulations or orders to place this delivery order, to receive the item(s) ordered for the purpose for which ordered, and to use any preference rating or allotment number or symbol which the undersigned has placed on this order.
>
> Name of operator
>
> Signature of designated official

Such certification shall be signed manually or as provided in Priorities Regulation No. 7.

NOTE: Paragraph (2), formerly (3), redesignated Jan. 5, 1944.

(2) The ratings assigned by this order may be extended by a supplier in the manner provided in Priorities Regulation No. 3, and CMP Regulation No. 3.

(f) *Restrictions on deliveries, inventory and withdrawals*—(1) *Deliveries and withdrawals.* No operator shall, during any calendar quarterly period, accept delivery of any material or withdraw from inventory any material, to be used for maintenance or repair or as operating supplies or for any other purpose (except material to be segregated for use in extensions specifically authorized under paragraph (g) (2) of this order or by an operative preference rating order or certificate issued by the War Production Board), the aggregate dollar value of which shall exceed the aggregate dollar value of materials used for maintenance or repair or as operating supplies, during the corresponding calendar quarterly period of the year 1942, or at the operator's option, twenty-five per cent of the aggregate dollar value of materials used for said

purpose during the operator's fiscal year ending closest to December 31, 1942.

(2) *Inventory.* No operator shall at any time, accept delivery of any material if the operator's inventory will, by virtue of such acceptance, be in excess of a practical working minimum.

(3) *Exceptions.* The provisions of paragraph (f) (1) of this order are subject to the following exceptions.

(i) An operator who, during the calendar year 1942 (or fiscal year ending closest to December 31, 1942), used for maintenance, repair, and as operating supplies, materials of the aggregate value of not exceeding $1,000 and whose estimated requirements for materials to be used for maintenance, repair and as operating supplies during any calendar year (or corresponding fiscal year) do not exceed $1,000 may, during such year, exceed the quantity restrictions prescribed by paragraph (f) (1) of this order. If the actual requirements of material for maintenance, repair and operating supplies for such year should prove to be in excess of $1,000, such operator shall not accept any deliveries of material or withdraw from inventory any material to be used for maintenance, repair or as operating supplies if such deliveries or withdrawals, when taken together with other deliveries or withdrawals within such year, would, in the aggregate, exceed $1,000. In such case the operator may apply for specific authorization to exceed such quantity restrictions pursuant to the provisions of paragraph (f) (4) hereof.

(ii) An operator may, in any calendar quarterly period, increase scheduled deliveries, and withdrawals of material required for maintenance or repair or as operating supplies over the limits prescribed in paragraph (f) (1) of this order, in proportion to the increase in the load on the system during the preceding calendar quarterly period of the year 1942 corresponding to the calendar quarterly period in question, determined by a measurement of the average daily flow for the two comparative periods: *Provided*, That in determining the average daily flow of sewage, any flow of surface storm water which enters the system shall not be taken into account.

(iii) An operator may, in any calendar quarterly period, accept deliveries of material or make withdrawals from inventory of material, necessary for the maintenance or repair of the operator's property or equipment which is damaged by acts of the public enemy, sabotage, explosion, or fire or by flood, storm or other similar climatic conditions: *Provided*, That if the restrictions of paragraph (f) (1) are exceeded because of such deliveries or use, a full report thereof shall be made within thirty days after such delivery or withdrawal, to the War Production Board.

(iv) An operator may, in any calendar quarterly period, accept delivery of material, having in the aggregate, a dollar value of not more than the dollar value of material of the same class taken from the operator's inventory for delivery to other persons authorized to accept delivery under applicable regulations of the War Production Board but

only if, and to the extent that such taking has reduced the operator's inventory of material below a practical working minimum.

(v) An operator may, during any calendar year (or his fiscal year), withdraw from inventory, material, having in the aggregate, a dollar value of not more than the dollar value of usable material of the same class salvaged from plant during such year.

(vi) The provisions of paragraph (f) (1) and (f) (2) shall not apply to fuel or to chemicals for sewage treatment.

(4) The War Production Board, on its own initiative, or on application of any operator by letter, in triplicate, addressed to the Government Division, War Production Board, Washington, D. C., Ref: P–141, may modify the limitations on practical working minimum inventory, and on scheduling or accepting deliveries, or on use or withdrawals, set forth in this paragraph (f).

(g) *Restrictions on construction of sewerage facilities.* No operator shall construct any sewerage facilities, including but not limited to sewer pipelines, manhole structures, pumping stations, sewage disposal or treatment plants and connections, and no operator shall, in case of contract construction, accept deliveries of material for such purposes except as follows:

(1) An operator may construct an addition to or an expansion of, sewerage system or works, other than buildings: *Provided*, That such addition or expansion shall not include any work order, job or project in which the cost of material shall exceed $1,500 in the case of underground sewer pipeline addition or extension, and $500 in the case of any other addition or expansion: *And provided*, That no single construction project shall be subdivided into parts in order to come below these limits: *And further provided*, That in making house connections or extension of line to serve premises, no iron or steel pipe shall be used except the minimum quantities required in making necessary connections.

(2) An operator may construct an extension of sewerage facilities, other than buildings, to serve premises which are being built or remodeled under authority of any Preference Rating order of the P–55 series, a specific authorization issued pursuant to Conservation Order L–41 or pursuant to any Petroleum Administrative Order issued by the Petroleum Administrator for War if all of the following conditions are satisfied:

(i) The cost of material for such extension does not exceed $5,000 (but exceeds $1,500 in the case of underground sewer pipeline extension or $500 in the case of any other extension).

(ii) The extension does not duplicate an adequate service already installed.

(iii) No other operator can render the same service with lesser amounts of critical material.

(iv) The extension will not cause an overload on system including sewage disposal plants.

(v) The operator has completed Form WPB–3445 and delivered it to the builder of the premises to be served for attachment to the builder's application for L–41 approval. Preference ratings and allotment number to acquire material required for such extensions are assigned by paragraph (h) of this order.

(3) In addition to the authorization contained in paragraphs (g) (1) and (g) (2) an operator may construct sewage facilities of any kind if such construction is specifically authorized by the War Production Board. Application should be made on Form WPB–617 (formerly PD–200) or on such other form as may be prescribed. The following preference rating orders or certificates include permission for construction under this order although they do not say so: PD–19–h, CMPL–127, CMPL–224. In all other cases a preference rating is not enough unless the instrument which assigns the rating also states that construction is permitted. However, any operator who prior to January 15, 1944, has been specifically authorized in writing by the War Production Board to use the lowest rating assigned to a rated project to obtain material to construct sewerage facilities to serve such project may use such rating to obtain material required for that purpose within the limits of said authorization.

(h) *Assignment of preference rating and CMP allotment symbol for extensions authorized under paragraph (g) (2).* (1) The preference rating AA–3 is hereby assigned to orders for material other than controlled material, and the abbreviated allotment number P–141–S2 is hereby assigned to orders for controlled material to be placed by an operator for use in the construction of extensions of facilities authorized by paragraph (g) (2) of this order or to replace in inventory material so used.

(2) The preference ratings and allotment number assigned by paragraph (h) (1) may be applied by an operator by using the certification provided in CMP Regulation No. 7. An order for controlled material bearing such certification and allotment number shall constitute a controlled material order.

NOTE: Paragraphs (i), (j), (k), (l), (m), and (n), formerly (h), (i), (j), (k), (l), and (m), redesignated Jan. 5, 1944.

(i) *Sales of material from inventory.* Any operator may sell to another operator, material from seller's inventory in excess of a practical minimum working inventory: *Provided*, That (1) a preference rating of AA–5 or higher assigned by this order or by any preference rating certificate, or (2) a specific direction issued by the War Production Board, is applied or extended to the operator selling such material.

(j) *Audits and reports.* (1) Each operator and each supplier who applies the preference ratings or allotment symbol hereby assigned, and each person who accepts a purchase order or contract for material to

which a preference rating or symbol is applied, shall submit from time to time to an audit and inspection by duly authorized representatives of the War Production Board.

(2) Each operator and each such supplier shall execute and file with the War Production Board, such reports and questionnaires as said Board shall from time to time request, subject to approval by the Bureau of the Budget as required under the Federal Reports Act.

(3) Each operator shall maintain a continuing record of inventory and of segregated material in his possession and all material used by him for maintenance, repair or as operating supplies.

(k) *Communications to the War Production Board.* All reports required to be filed hereunder and all communications concerning this order shall, unless otherwise directed by the War Production Board be addressed to the War Production Board, Government Division, Washington, D. C., Ref: P–141.

(l) *Violations.* Any person who wilfully violates any provisions of this order or who, in connection with this order, wilfully conceals a material fact or furnishes false information to any department or agency of the United States, is guilty of a crime and, upon conviction, may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using material under priority control, and may be deprived of priorities assistance.

(m) *Revocation or amendment.* This order may be revoked or amended at any time as to any operator or any supplier. In the event or revocation, deliveries already rated pursuant to this order shall be completed in accordance with said rating, unless the rating has been specifically revoked with respect thereto. No additional applications of the ratings to any other deliveries shall thereafter be made by the operator or supplier affected by such revocation.

(n) *Applicability of regulations.* (1) Preference Rating Order P–141 is issued in lieu of Preference Rating Order P–46 in so far as it affects public sanitary sewerage systems as defined in paragraph (a) (1) hereof and any reference in any order or regulation of the War Production Board to said Preference Rating Order P–46 shall constitute a reference to orders in the P–141 series.

(2) This order and all transactions affected hereby, except as herein otherwise provided, are subject to all applicable regulations of the War Production Board as amended from time to time, *Provided*, That none of the provisions of CMP Regulations No. 5 or No. 5A shall apply to operators as defined in paragraph (a) (1) hereof, and no such operator shall obtain any material under the provisions of either of said regulations.

Issued this 5th day of January, 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

OPERATION OF TRICKLING FILTERS*

By Frank Bachmann

Engineer, The Dorr Company

The trickling filter is the most widely used type of secondary or final treatment process in this country. The Massachusetts State Board of Health is given credit for introducing coarse stone filters as a result of their work at the Lawrence Sewage Experimental Station, where in June 1889, two experimental rock filters were constructed and dosed with sewage. Difficulty was encountered with pooling and septic action. Corbet of Salford, England, is responsible for further development of the coarse stone filter by improving the distribution of the sewage onto the filter and the use of false bottoms with underdrain system.

It was not until 1905 that the first trickling filter was constructed at Columbus, Ohio. However, Reading, Pennsylvania, put the first plant into operation in 1908. From 1940 to 1925 all large and practically all small sewage treatment plants used trickling filters for secondary treatment. Also, during this same period the activated sludge process was being studied experimentally. From 1925 to 1936 the activated sludge process became the "style" for secondary treatment and hundreds of these plants were constructed for both large and small communities.

Recently the trickling filter has come into its own again, principally due to the development of increased capacity of these filters which reduced the initial and operating costs, and also eliminated to a large extent some of the operating difficulties of the low rate filter. Both low rate and high rate trickling filters were constructed in Army, Navy, and Defense plants during the past three years. Other types of secondary treatment processes were also installed, but these are by far in the minority.

The records of operating results of the trickling filter plants in these installations have proven the good judgment of the designers. This process has successfully handled the shock loads in Military installation, which are at least twice those encountered in the average municipal sewage treatment plant. Also, these trickling filter plants have been called upon to handle population loads far in excess for which the plants were designed. Under these conditions they have continued to function even though with a decrease in efficiency commensurate to the load placed upon them. Other types of biological processes under these overloaded conditions give no end of trouble. The trickling filter process can be abused by an overloaded condition and still "take it."

A trickling filter is a bed of stone from 3 to 10 feet deep, provided with proper underdrainage, ventilation, and method of distributing the sewage. The stone size ranges from ¾ inch to 3 inches, usually 1½ to 3 inch. Larger than 3 inches has been used in some types of high rate filter processes. Theoretically, at least, one would expect greater puri-

* Presented at Georgia Water and Sewage School, October 8, 1943.

fication from the smaller size stone because of a greater exposed area. Stone which is small is apt to clog more readily than stone of larger size. Definite specifications have been set covering the characteristics of the stone used for trickling filters by the American Society of Civil Engineers. These specifications are rigid and if followed will avoid many of the difficulties in filter operation due to disintegration of the stone. The proper design of the trickling filter is the responsibility of the Consulting Sanitary Engineer and it is his function to design for ample capacity, underdrains, and ventilation. This discussion will be confined to operation and not to design features of the trickling filter.

Settled sewage is distributed onto a filter bed by means of sprays, either the old fixed nozzle type or by means of revolving distributors on circular beds. Rectangular beds with distributor mechanism are rare in this country. Dosing tanks are usual with low rate filters, but are not required with high rate types of filters, because of the continuous high volume of flow to the filter.

The trickling filter in the past was called "percolating" and "sprinkling" filter. In a true sense, it is not a filter as the voids between the stone are too large to strain out any of the applied solids. The trickling filter functions somewhat similar to the activated sludge process. Both processes are dependent on biochemical and physical reactions in the presence of dissolved oxygen. In the activated sludge process, the purifying media is kept in contact with the sewage by agitation and recirculation; whereas, in the trickling filter the purifying media is stationary and the sewage passes over this media.

Purification in a trickling filter depends upon many forms of plant and animal life. Holtje, of the New Jersey State Dept. of Health, states that these organisms are represented by:

Bacteria—with which you are all familiar.
Fungi—moulds and yeast.
Algae—filaments of small plant life.
Protozoa—small single cell animals.
Nematoda—very small round thread or round worms.
Rotatoria—small animals which pull the material toward them by wheel action.
Chaetopoda—small bristle-bearing worms.
Crustacea—snails and hard shell animals.
Arachnida—spiders.
Insecta—flies and other insects.

Microscopic examination of the film on filters discloses a mass of bacteria, the various forms of life mentioned above, and particles of solids attached or enmeshed in the film. All of these organisms have an important roll in purifying the sewage. Even the objectionable Psychoda fly plays its part in one way or another. Finely divided suspended matter and colloids are converted to flocculent matter. Bacterial count and organic content are reduced in passing through the filter.

Very little purification takes place in a trickling filter during its early stages of operation. It is only after a gelatinous film surrounds the stone that purification takes place. Early observers were of the opinion that the sewage did not pass directly through the filter, but displaced the water contained in the gelatinous film very much like pouring water on top of a sponge. The soundness of this theory is questioned with the flow rates used in high capacity filters. In any event, the contact between the sewage and biological life developed on the stone results in purifying the sewage. All of this contact does not necessarily take place in the filter as some contact takes place between the sewage and solids in the final sedimentation tank.

The action of the mass of biological life on the filter stone in purifying sewage might be compared to feeding hogs garbage. The hogs keep on their feet feeding but if the supply of garbage is more than necessary, the hog will eat lying down. The biological life on a filter should be given sufficient food for their healthy development, but if overfed they lie down on the job, and we have what is termed an overloaded condition. Dissolved oxygen in the sewage is necessary for the correct type of growth on the stone. With an overloaded condition the growth is insufficient to take care of the load and the result is that the organic matter becomes septic, thus destroying the biological life responsible for the aerobic digestion of the organic matter. The filter is then termed to be sewage sick. Ponding and odors on the filter result from this condition.

On low rate filters, solids accumulate on the stone, more particularly during winter months when biological activity is not great, and these solids slough off periodically. This sloughing takes place usually in the spring when bacterial and other forms of life become more active due to higher temperature. Sloughing is also common early in the autumn, which indicates that the filter accumulates solids to an extent where certain forms of life start their work of digesting and loosening up the mat of solids giving the sewage a chance to wash them from the filter.

At times of heavy accumulation of solids on the stone, observers have noticed that fly nuisance is at its worst. The effluent from the filter is also at its worst during the sloughing period, in fact it is sometimes higher in B.O.D. than the raw sewage.

No periodic sloughing on high rate filters has been observed, as these filters unload continuously because of the flushing action of the high flow through the stone.

Flamentous bacterial growths on the stone are usually prolific. These growths are usually made up of Beggiatoa, Sphaerotilus and Cladothrix. Bright or blue green algae are common on the surface of a properly operated filter which is exposed to sunlight. These algae while abundant do not grow to the extent of clogging the filter as their growth is confined to the surface. The other types such as the gray colored Beggiatoa, Sphaerotilus and Cladothrix, and the sewage fungus Leptomitus will, under certain conditions, retard percolation. The

writer recalls a mat of these organism 10 to 12 inches thick on the surface of an experimental filter at New Britain, Conn., during the early spring of 1921. Pooling was observed with each dose, but the water seeped through the mass before the application of the next dose of sewage. Purification was high during this period. Later, as the temperature of the sewage increased the mat disappeared.

The standards of a good effluent from sewage treatment plants have changed in the last fifteen years. A trickling filter, or an activated sludge effluent, was not considered satisfactory unless high nitrates were present in the effluent. Since then plants have been designed with either process to give clarification only and not nitrification. This has permitted higher B.O.D. loadings with these processes. The low rate trickling filter, for instance, was formerly designed for a B.O.D. applied filter loading of 350 pounds per acre foot, but the Army uses 600 pounds, or more than a 50 per cent increase. The high rate filters use an applied B.O.D. loading of 3,000 pounds per acre foot, which is 5 times the loading of low rate filters. Nitrites and nitrates in the effluent are low with both types of plants.

At a sewage plant recently visited using a high rate filter and where the raw sewage contained high nitrates from industrial wastes, the final effluent showed less nitrates than was present in the raw sewage, indicating denitrification to some extent. It is not necessary to obtain nitrification to produce a satisfactory effluent. The advantages of producing a thoroughly nitrified effluent are not commensurate with the cost. A highly nitrified effluent is apt to encourage prolific growths of green algae in the stream into which it is discharged. This was true at an activated sludge plant at Folsom Prison, California, where an effluent high in nitrates caused mats of algae to grow in the canal into which the effluent was discharged. These algae loosened from the banks of the canal and clogged the intake screen of a power plant, resulting in a complaint from the power company. The difficulty was solved by constructing an outfall direct to the river.

The treatment of trickling filter effluent by sedimentation is essential to remove the settleable solids. In the early days of trickling filters no final sedimentation was installed. Later, short detentions were installed, but today as much attention is given to settling trickling filter effluent as is given to the sedimentation of raw sewage. In fact the detention time is the same for both raw and filter effluent. Adequate sedimentation of the effluent removes approximately 50 per cent of the suspended solids and B.O.D.

On the average, an adequately designed trickling filter plant will remove 85 per cent B.O.D. and about 90 per cent of the suspended solids. Better removals will be obtained when the plant is overcapacity and inferior results when the plant is undercapacity. A single stage Biofiltration plant, with a split recirculation volume totaling 1.5 : 1 of sewage flow, will give approximately the same purification as a low rate trickling filter.

All sewage plants have their troubles. The main troubles with trickling filters are: odors, nozzle clogging, pooling and flies.

Odors on the filters may be caused by the stale or septic conditions of the sewage as it enters the plant. If the sewage is septic, the entrained foul gases are liberated when the sewage is sprayed on the filter. These odors may be particularly offensive during warm humid nights. Pre-chlorination of the raw sewage to point of a few tenths residual in the primary clarifier effluent will usually eliminate odors on the low rate filter. Care should be taken not to add chlorine sufficient to destroy the bacterial film on the stone. Recirculation of filter effluent to the raw sewage also eliminates odors.

Nozzles should be inspected daily and orifices partly or completely clogged should be cleaned. Inspection of the clogging material will often indicate its source and steps should be taken to eliminate this material from getting into the nozzles. One source is from the ineffective skimming of the primary tanks. This is especially true where hand skimming alone or in connection with some types of mechanical skimmers is practiced. The operator is usually anxious to get the job finished and in doing so pulls the scum to the scum trough too fast, resulting in considerable scum passing over with the effluent. This scum is often the cause of the nozzle clogging. A number of the older types of plants and a few of the newer plants with poor skimming arrangements practice screening of the primary effluent to protect the nozzles. Screen openings are usually slightly smaller than the openings in the sewage distributors.

The dosing tank walls should be kept free of grease and algae accumulations because when this material loosens it will clog the distributor nozzles.

Fungus and algae growths are beneficial in purifying sewage so there is some question as to the advisability of keeping the weir ledges and channels free of these growths. They should not be permitted to accumulate to the extent that permits the lower layers of these growths to become septic.

Distribution piping and underdrains should be flushed periodically where this is possible. Pooling is quite common on low rate filters which are operating over their design capacities. This is particularly true where prechlorination or periodic flooding is not practiced. Pooling is caused by overloading, excessive growths of filamentous algae on the stone, leaves blown on the filter, and small size stone due to disintegration or placed in the filter during construction. Pooling can be eliminated by applying high dosage of chlorine, raking or forking the surface, resting the filter for several days, punching holes through the top layer with iron bar, and by flushing the surface with fire hose. Stone that has disintegrated is best removed and replaced by better type material.

The Psychoda flies are abundant on all low rate filters unless special measures have been taken to control them. The eggs of this fly are layed on the filter stone by the adult fly. These eggs hatch into larvae

in about 2 days during warm weather and in the next 8 to 15 days develop into the adult flies. The average time between broods is about 2 weeks. The larvae are usually found to a depth of from 3 to 12 inches below the surface of the filter stone.

Attempts have been made to control flies with various chemicals such as ammonia, kerosene, kerosene and pyrethrum flower, kerosene and orthodichorobenzene, creosote and chlorine. The cost of chemicals is high and the results have not been entirely satisfactory. Chlorine has given the best results of any of the chemicals tried, but with its use there is always the chance of destroying the biological film on the stone. If chlorine is used, it should be applied during the low flows at night to reduce the amount required. Chemicals have been applied either to the filter influent or sprayed on the surface of the filter.

Dichlorobenzene in an emulsion with paraffin oil has been used effectively for spraying the walls to kill adult flies. A flame has also been tried to burn the flies on the walls of the filters. Unless these measures are kept up frequently they are a temporary relief only.

After much experimenting the universal practice is to flood the filters every 7 to 10 days, this period being within the life cycle of the pest. The filter is usually flooded for a period of 24 to 36 hours. By this means the larvae are drowned.

It is important that every inch of the surface of the filter is covered by the distributor sprays. Any areas which are missed or slightly wetted will harbor fly larvae. The writer has seen filters that had been operating for months which had a 6- to 10-inch space at the periphery of the filter that was not touched with the spray. Simple adjustment of the nozzle corrected this condition. An opening in the end of the arm of the distributor to give a spray against the wall will wash any flies crawling up the filter walls back down through the filter. Flushing the surface of the filter with a fire hose has been tried, but without much success. Retarding the speed of the distributor manually so as to give a high rate application of sewage has been successful in controlling flies but is a tedious procedure.

Filter flies are not a serious problem on high rate filters. The high velocity of the sewage passing through the stone continuously washes the larvae out of the filter bed. Flies are present in some types of so-called high-capacity filters but only where the dosing rate is insufficient to properly flush the filter continuously.

Many operators wish to eliminate entirely the Psychoda fly larva from the filter. Investigators believe that fly larvae should be credited with a considerable amount of the digestion of the organic matter deposited on the stone and also the wigglers keep the material loosened up.

A general knowledge of the functioning of the dosing siphon and revolving distributor is helpful to the operator. It is assumed that the dosing tank and distributor have been set according to the elevations and dimensions shown on the manufacturer's drawings. A discrepancy in elevation may seriously affect the capacity of the distributor at its designed flow.

The feed piping should be tested for leakage, and the small piping attached to the bell of the siphon should be absolutely air tight. The high water level at which the siphon starts operating is set by the length of the upstanding nipple of the compression seal. If the water rises too high flowing over into the overflow pipe without blowing the seal, this nipple must be shortened. Conversely, if dosing starts too soon the nipple will have to be lengthened.

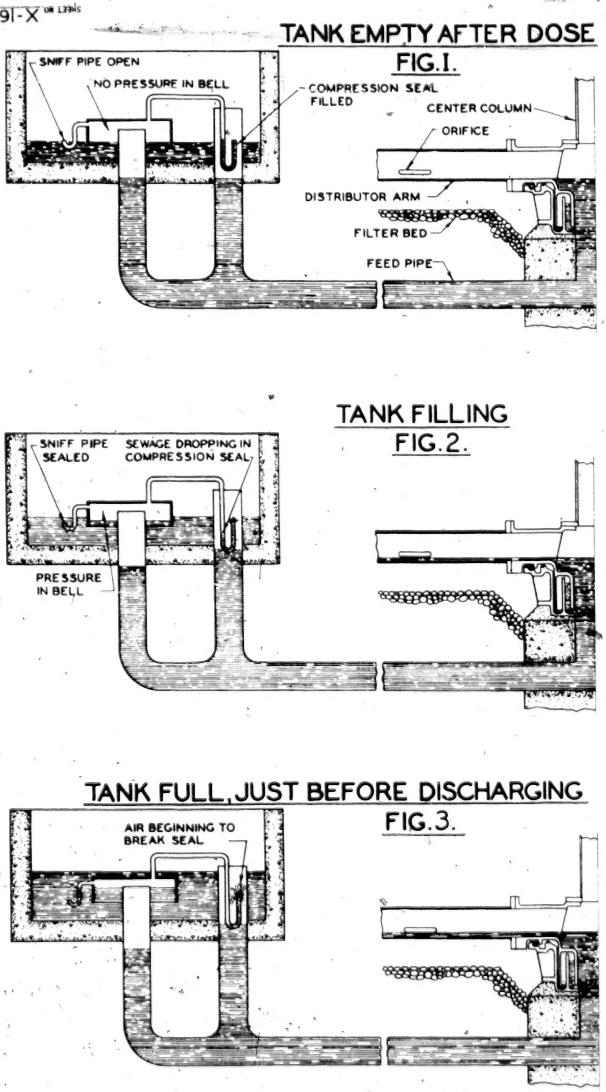
In operation, at the close of the dosing period, the sewage remains in the feed and overflow pipes at the elevation of the bottom of the distributor arms and some liquid also stays in the return bend inside the overflow pipe. At the same time the level in the tank is slightly below the sniff pipe opening all as indicated in Fig. 1. As the level rises in the tank, the sniff pipe is sealed, trapping and compressing a definite quantity of air under the bell which forces water to be spilled gradually out of the return bend, or compression seal, into the overflow pipe. This condition is indicated in Fig. 2. When the predetermined high water level is reached, as in Fig. 3, the trapped air reaches a pressure sufficient to blow the water out of the compression seal permitting the siphon to flood and start flow to the distributor. The restriction created by the orifices in the arms causes the flow to back up in the overflow pipe flooding the compression pipe end and refilling the seal for the next dose. (See Fig. 4.) As the flow continues out of the orifices, the levels in the overflow pipe and center column drop rapidly corresponding to the fall in the dosing tank (Fig. 5). When the level drops below the opening in the sniff pipe, air is admitted into the bell breaking the siphon and stopping the flow to the distributor. The dosing tank then starts refilling and the cycle described above is repeated automatically.

A sewage distributor is a self-propelled rotating device for distributing sewage over a circular bed of filter stone. The rotation is obtained by the reaction of the water flowing out of a series of orifices spaced along the arms.

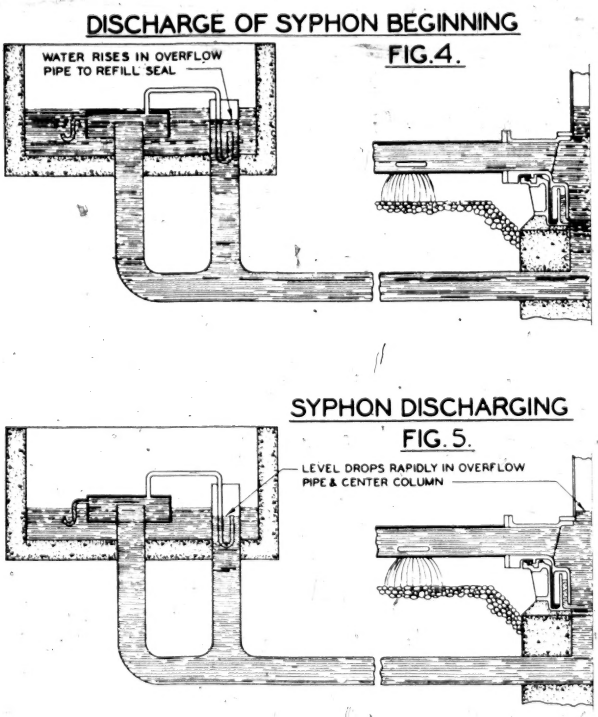
The distributor mechanism consists of a central ball bearing turntable to which are attached radial arms usually supported by guy rods from the top of a tubular center column. The base casting is securely bolted on a hollow concrete pier into which the feed pipe terminates. The turntable top is essentially a hollow well arranged to distribute the flow properly to the arms. The turntable contains a special seal to prevent entrance of sewage into the bearing under all normal operating conditions. The ends of distributing arms are equipped with lever operated quick opening gates or covers to permit flushing while the machine is operating.

Should the sewage spray out of the orifice without rotating the mechanism, either the turntable is not working freely, or else there is insufficient head to operate the unit. The elevations of the arms and high water in the dosing tank should be checked with the drawings. If the elevations are correct then the trouble may be in the turntable assembly. The bearing balls and race should be flushed out with light oil

991-X OR LESS



FIGS. 1-3.—Illustration of trickling filter syphon operation. (Courtesy The Dorr Company, Inc.)


DISCHARGE OF SYPHON BEGINNING
FIG.4.
WATER RISES IN OVERFLOW PIPE TO REFILL SEAL
SYPHON DISCHARGING
FIG. 5.
LEVEL DROPS RAPIDLY IN OVERFLOW PIPE & CENTER COLUMN

FIGS. 4–5.—Illustration of trickling filter syphon operation. (Courtesy The Dorr Company, Inc.)

or kerosene and if this does not correct the condition, the center mechanism should be jacked up for a thorough cleaning and inspection of the balls.

The hardened steel inserts on which the balls ride are renewable and plugged holes have been provided in the castings through which one end of each strip can be forced out of its recess. Originally these inserts are smooth, but during the first few weeks of operation, the balls roll small grooves in them until proper contact area is obtained. This slight grooving is a normal condition and does not signify excessive wear provided the surface is smooth. Usually these grooves will vary from ⅛ inch to ¼ inch depending on the size of mechanism and load on the bearing. In cases of excessive wear or pitting of the races it is practical to reverse the inserts to provide a new working surface.

At least once in six months the mercury should be drained completely and the seal flushed out by hosing through the hand hole in the opening in the turntable top casting. On some machines with cone shaped cen-

ter columns, a partition plate at the base of the column prevents access to the seal well; in such cases flushing may be accomplished through the mercury fill pipe. In any case, the mechanism should be revolved so that the point of flushing is diametrically opposite the drain and a receptacle kept under the drain to catch any mercury that may be forced out. Thoroughly wash the collected mercury by adding water, shaking vigorously and decanting, repeating until clean. The mercury may be cleaned of grit and water by placing on a dampened chamois skin; the water will pass through the chamois and the mercury be poured off leaving grit particles adhering to the chamois. It may be necessary to repeat this process to effect a thorough cleaning.

In case the mercury has become badly sludged the turntable mechanism may have to be raised to salvage all of it out of the seal well and a more drastic cleaning procedure followed. In order to dissolve the grease a mineral solvent such as naphtha should be used first. This is followed by treating the mercury with a 50 per cent concentrated solution of nitric acid after which it is given a bath of sodium bicarbonate to neutralize the acid. Then after two or three washings in water the mercury will be ready for use.

Carefully weigh the mercury before replacing it in the machine by adding whatever amount is necessary to equal the quantity originally furnished. This is important as an inadequate mercury seal will result not only in unsatisfactory operation of the machine, but very probably in further loss of mercury and damage to the turntable bearing through contamination of the oil with sewage, may rapidly corrode the balls and raceways.

It is advisable to drain the oil out and flush the bearing balls and raceway after the first week of operation and thereafter once every month. A low viscosity oil (about SAE 10) with rust inhibitive properties is recommended. It is also recommended that once per week the oil drain be opened to allow elimination of water that has accumulated due to condensation or other cause. On such occasions, check the oil level by inspection of the gauge and add oil if necessary. If the presence of any steel particles or other foreign matter is noted, all the oil should be drained immediately, the turntable flushed and fresh oil added. This draining and flushing should then be repeated at least once per week until the lack of foreign matter is evident.

Both fixed nozzles and revolving distributors are exposed to moisture, sewage gases and oxygen from the air. This condition is ideal for corrosion. Nozzles should be replaced when worn and metal parts subject to corrosion kept well painted. A stock of spare parts should be kept on hand.

The proper operation of the final clarifier is important to obtain the best results from trickling filters. A sludge pump is installed to convey the sludge from this unit back to the raw sewage. This pump is usually operated just long enough to remove the solids. Experience has indicated that the pump should be operated continuously on a short stroke

to eliminate the human element from the pump schedule. This procedure will remove the solids from the final clarifier continuously and prevent accumulation of septic sludge in this unit.

It is good practice to by-pass the final clarifier for the first week or two during initial operation. This will eliminate fine stone and dust washed from the filter from depositing in the sludge lines and in the digesters. Very little purification takes place in the filter during this period, consequently, the effluent is not impaired by this procedure.

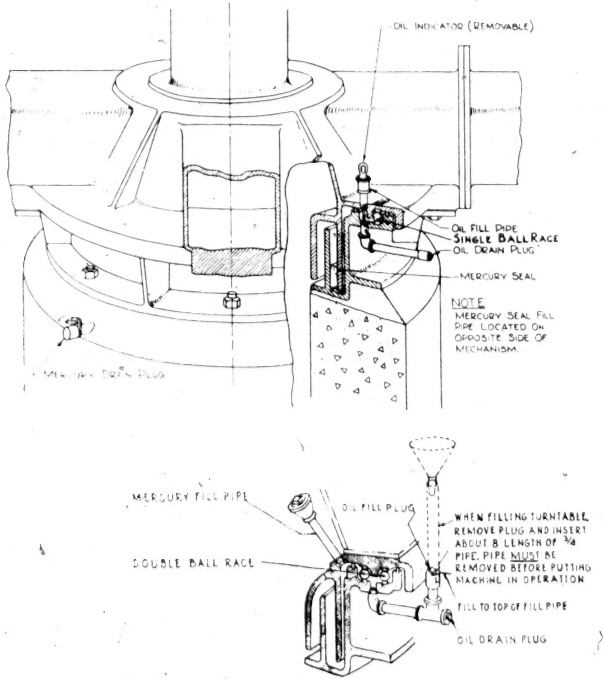

OIL INDICATOR (REMOVABLE)
OIL FILL PIPE
SINGLE BALL RACE
OIL DRAIN PLUG
MERCURY SEAL
NOTE
MERCURY SEAL FILL PIPE LOCATED ON OPPOSITE SIDE OF MECHANISM.
MERCURY FILL PIPE
OIL FILL PLUG
WHEN FILLING TURNTABLE, REMOVE PLUG AND INSERT ABOUT 8" LENGTH OF ¾" PIPE. PIPE MUST BE REMOVED BEFORE PUTTING MACHINE IN OPERATION
DOUBLE BALL RACE
FILL TO TOP OF FILL PIPE
OIL DRAIN PLUG

FIG. 6.—Lubrication arrangement at doube ball turntable (Dorr).

The trickling filter has been with us for forty years and will continue to be with us for many more years. The development of this filter with high capacities is one of the simplest means of reducing the initial and operating costs of this much abused method of sewage treatment. Several plants with low capacity filter have increased their capacity by recirculation of filter or final effluent to the raw sewage or ahead of the filter, thus converting these filters to high rate units.

OUR MISTAKE—TWICE!

Chemist Robert S. Ingols, formerly associated with Superintendent A. F. Lehmann at Hackensack, New Jersey, calls our attention to an error made in reporting the experience at that plant as part of the article "Experience in Diffused Air Activated Sludge Plant Operation," published in the September, 1943 issue of *This Journal*. In the first paragraph on page 925, it is erroneously stated that "a drop in pH occurs during normal operation and that bulking occurs otherwise." In correction, the statement made by Mr. Lehmann regarding pH is quoted herewith:

FIG. 1.—Arrangement for flushing diffuser tubes with water at Rockville Centre, N. Y.

"The degree of oxidation of the sludge is determined by taking the pH of the aerators. As the purification proceeds, the pH in the aerators drops. Too low a pH indicates that the sludge will rise in clumps; while a failure to have a low pH means that there is insufficient oxidation and bulking will follow."

Unintentional injustice was also done Superintendent C. George Andersen of Rockville Centre, New York, in our implication on page 934 of the same issue that a water supply cross-connection was probably involved in his arrangement for flushing diffuser tubes with water

under pressure. Mr. Andersen assures us that the procedure has the sanction of the New York State Department of Health and provides us with a detailed description of his practice in flushing the tubes.

Figure 1 illustrates the arrangement. A plugged tee in the individual air pipe to each tube unit is opened after the air is shut off, a nipple is screwed into the tee and a snap water hose connection is hooked up. Water is then applied through the hose for two minutes after which the water hose is disconnected, the tee plugged and the air flow restored. Each diffuser tube unit is flushed weekly in such fashion. It will be noted that the city water connection is maintained only while the flushing operation is being performed under strict supervision.

Our sincere apologies to Messrs. Lehmann and Andersen.

KINDS OF LIME SUITABLE FOR USE IN SLUDGE DIGESTION TANKS*

By Joseph Doman

Sanitary Engineer, Greenwich, Conn., Public Works Department

In giving consideration to the suitability of various kinds of lime for use in sludge digestion tanks, I am merely going to give a brief summary of our experience at the Greenwich disposal plants and not present a scientific treatise on the subject.

Our experience includes the use of three kinds of lime, unslaked, partially slaked and completely slaked or hydrated. At the present time we are using the hydrated lime as we find this the most easily obtainable lime suitable for our own particular conditions.

Lime packed in 50-lb. bags is most convenient for our own use. Some limes used in plastering contain considerable magnesium. Theoretically, the hydrated magnesium should be just as effective in neutralizing acidity as the hydrated calcium. The hydrated calcium, however, is more soluble than the magnesium and less apt to precipitate into the sludge, hence we prefer the lime to have a low magnesium content. In this connection I have some analyses of several commercial brands of lime. A brand of granular (unslaked) lime shows approximately 95 per cent calcium oxide and 1 per cent magnesium oxide. A brand of fully hydrated lime shows approximately 73 per cent calcium oxide and 1 per cent magnesium oxide. This is the lime we are now using. Another brand of hydrated lime used for special plastering purposes shows approximately 50 per cent calcium oxide and 33 per cent magnesium oxide.

From the standpoint of current prices, the hydrated lime costs about a cent a pound and the granular about 20 per cent more. Taking the lime analysis into consideration, the granular lime provides

* Presented at Boston meeting of New England Sewage Works Association, Sept. 22, 1943.

about 10 per cent more calcium for the same cost than the hydrated we are now using.

This slight cost advantage, however, is more than counterbalanced by ease of application and saving in operating time with use of the hydrated lime. In applying the hydrated lime, we merely shovel it into a manhole or sampling sink, mix and agitate with water and pump directly into separate digesters with either the sludge or recirculating pumps. At two of our plants we apply the lime directly to digesting material in old septic tank units used only for digestion. In this case we add the lime during recirculation, using the recirculated liquid for mixing and agitation. These procedures are very simple and rapid.

With the use of the unslaked lime, however, we would have to provide facilities for slaking and allow sufficient time for the slaking reaction to become complete. This is a rather messy and time-consuming procedure, and for our small plants is probably less economical in the long run than the use of hydrated lime. Where lime is used in ton lots rather than bag lots and proper facilities for slaking and mixing are provided, the use of a good grade of unslaked lime would probably be less costly than the use of hydrated lime.

We have also had experience with a partly slaked lime which was called "agricultural" lime. This required the same procedure for slaking and mixing as the unslaked lime but did not require as much time for slaking. This was used at a plant where we had a 1½ inch centrifugal pump for recirculating and pump cloggages often occurred when pumping the lime into the digester.

Our present procedure with the hydrated lime is regarded as very satisfactory and we get good mixing and dispersion of the lime throughout the digesting material. Three or four times, however, during the past two years, the lime has apparently precipitated as the pH in the sludge rose to about 8.3 while the supernatant was about 6.9. This condition was easily remedied, however, by recirculating the bottom material back through the upper portions of the tank.

In adjusting our pH we find that good digestion takes place with a pH of 6.8 or 6.9. When the pH drops to 6.6, more lime is added.

The above remarks pertain to our own four plants which range in normal flow capacity from 0.25 million gallons to 2.5 million gallons per day. Larger plants and varying conditions would probably yield different experiences.

THE DAILY LOG *

September 3—It would seem that women are determined to have equal rights with men! With manpower inadequate there appears to be a concerted move toward a womanpower problem as well—at least it appears that way to us as we seek a replacement for our efficent office secretary. This is the fourth time in two years that Cupid has interfered with our office staff!

* From the 1942 daily records of the Urbana-Champaign (Illinois) Sanitary District.

Yet, as we pause to think a bit, hasn't womanpower always been a problem?

September 7—Labor Day, and rightly so named. Spent most of it in conference with a WPB representative, developing a questionnaire for use in determining estimates of critical materials required by the sewage works field. Eventually proved to be time well spent!

September 12—Have been needing some 6-inch I-beams which are scarce as platinum these days. Located some today which had originally been floor stringers in a small highway bridge which was wrecked by the tornado last year.

Patience was a good substitute for priorities in this case!

September 15—The Commissioner of Public Works of one of the cities in the District informed us today that a 10-inch abandoned sewer connection had been discovered and broken, at which point water from a creek had been flowing into the city sewers for years. We had been trying earnestly to impress upon him that the city sanitary sewer system obviously had many surface water sources but this one incident accomplished more in convincing him than all our past pleas lumped together.

Perhaps we shall get somewhere now!

September 20—Our operator-foreman, who had been critically injured by a fall into the empty final sedimentation tank last August 10, was able to leave the hospital and return to his home today. Ultimate recovery will be several months away but we are mighty grateful that he is on the way.

September 21—The long-expected has happened. For some time it has been apparent that the anchor plate welds holding the traction rail of the final

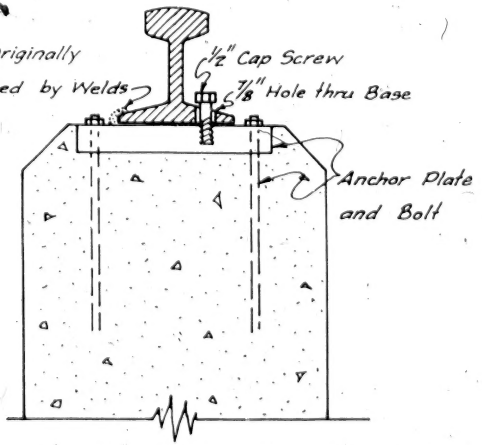


FIG. 1.—Improvised method of fastening clarifier traction rail to allow for expansion and contraction.

sedimentation tank clarifier were going to fail. Today that took place—with a vengeance! The rail came completely loose and skewed around the top of the square tank in such fashion that the clarifier wedged against the wall, the overload cut-out preventing any serious damage. The original welds were destined to failure from the beginning since they did not allow for temperature expansion and contraction in the rail.

Attempts to devise a clamp arrangement to hold the rail were unfruitful but an extremely simple solution, particularly advantageous because it could be accomplished with little critical material and performed by our regular personnel, was forthcoming (see Fig. 1). A hole 7/8 inch in diameter was drilled into the base of the rail at each anchor plate and the anchor plates drilled and threaded to receive 1/2-inch cap screws, which were not pulled up tightly. The 3/8-inch movement allowed the rail has proven adequate to permit normal temperature action.

September 23—To Chicago to give two lectures at the Army Sewage Works Operators Short Course given at the Illinois Institute of Technology. Enjoyed it immensely!

September 30—Patching the weathered edges of the concrete roof of the trickling filter pipe gallery, using the Truscon-Ferritex and Iso-Vol procedure described in a previous "Log." Have had very good luck with the method.

October 1—Several days ago, we promised a local farmer that we would let him have for the hauling, all of the sludge removed when the drying beds were next cleaned. Today, another farmer asked to be allowed to take the next cleaning after that. Looks like the stock pile is in for a rest.

Stand in line, friends, there's plenty to go around!

October 8—Despite the dearth of extra labor, we had to let a good man go because of his excessively free imbibing of the juice of the grape and grain. He practically splashed to work this morning!

Compensation, though, in the offer of one of the regular men to work a double shift until we could find a replacement.

October 20—Celebrated birthday by travelling to Cleveland for the Federation's First Wartime Sanitation Conference. Plenty of work but a good meeting and a good time!

November 2—Engaged in levelling and clearing the sludge stock pile so that the supply will be conveniently accessible to users. Seems to be an unusually heavy demand this fall and we are glad to facilitate removal of the sludge from the property.

November 5—Another safety inspector—this time from our compensation insurance company. Had only two recommendations, i.e., application of a non-skid paint to the step and floor at the doorway to the filter pipe gallery and provision of a constant ground from the electric motor mounted on the portable Marlowe pump. Both readily accomplished.

November 10—Took down the screenings grinder (hammer-mill) for inspection, repair and adjustment, an annual routine. Considering the work required of it, this equipment is most sturdy and serviceable. Replaced the hammers for the first time, the originals having given good service for six years.

November 16—The day the tax-payers of the community have been looking forward to for the past twenty years! Sent in a check in the amount of $51,125 to retire the last bonds and pay the final interest on the bond issue by which the intercepting sewers and sewage treatment works of this District were originally financed.

Our Board of Trustees is rightfully proud of the District's financial position. With no outstanding indebtedness and about $40,000 available in the construction account, it will be possible to proceed with the postwar construction badly needed extensions without resorting to another bond issue.

November 28—Professor Babbitt and his entire class of three (count 'em) sanitary engineers out for the annual inspection trip. At least, our profession is an exclusive one!

December 2—Zero this a.m. Troubled with ice formation on traction rail of final tank clarifier.

December 4—A foot of snowfall overnight, a heavy one for this region. Broke out the snow plow to clear roads and drives.

December 6—Completed replacement of the control piping at the twin, alternating siphons of the trickling filters. The old piping, in service for seven years, was in good condition below the water line where a protective grease coating had accumulated. Above the water line, nearly all of the joints were badly corroded and several were completely perforated, due to exposure to the dampness and corrosive gases at this location. Where the galvanizing was intact, the pipe was not seriously affected, the failures occurring where threads were exposed at the joints.

Installation of the necessary new piping was readily effected, with all above-water joints being given a coat of rust-inhibiting primer and two coats of asphaltic paint. Another improvement was made in the replacement of certain elbows with plugged crosses so that all lines can be conveniently and effectively flushed as part of the maintenance routine.

December 9—The continued cold weather has now resulted in almost solid freezing of the gas vents of the Imhoff tanks, causing ebullition of gas and belching of solids through the slot and into the settling channels. Nothing to be done about it but to keep the channels skimmed.

December 19—Temperature above freezing for several hours yesterday, permitting the gas vent water sprays to be used to submerge and reduce the frozen scum. This morning, gas ebullition was again taking place at the gas vents and the belching at the slots had entirely abated.

December 30—Inspector for the State Factory Inspection Division here to inspect the overhead cable safety belt suspension installed at the Imhoff tanks

at the order of that agency (described on page 738 of the July, 1943 issue of **This Journal**). The arrangement provided met with the approval of the inspector. Too bad the operator, who must use the device when skimming the tanks, is not so well pleased with it!

December 31—Scoured the property for scrape metal to be sold in accordance with instructions of the Salvage Division of the War Production Board. With which wartime note we leave 1942 and prepare, with mingled misgivings and hope, to greet 1943.

A WASTE GAS LINE WINTER HEATER

By E. A. Tschida

Superintendent, Dickinson, North Dakota, Sewage Disposal Plant

Gas production began in December 1939 at the Dickinson Sewage Plant. When zero weather came we found that due to the moisture in our sludge gas, the line to the waste burner would freeze up. We also discovered that the freezing point was at the ground line. During the first winter the line had to be dug up and thawed out so as to continue operations. This went on for two years when the idea came to us to build an oven or heater, as shown in the sketch below, which has worked out very successfully. The waste burner is shown to be inclosed for about three quarters of the way up, which gives ample heat and protection to keep the line from freezing. The first year, the temperature dropped to 42 below zero, giving our idea the acid test. This heater is ideal for any of the northern plants where subzero temperatures are common.

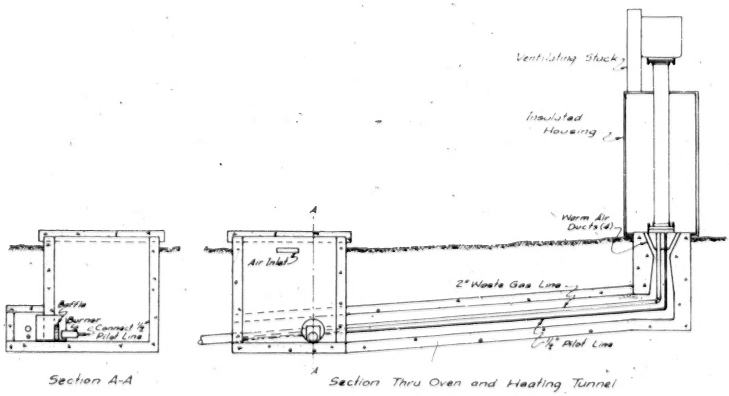


Fig. 1.—Winter heater for waste gas line and burner. Designed by E. A. Tschida, Superintendent, Dickinson, North Dakota.

WIRE FOR VACUUM FILTERS*

By John R. Szymanski

Supt., New Britain, Conn., Sewage Treatment Plant

Generally speaking, a topic for discussion at an operators' symposium usually deals with subject matter common to all. When I was asked to open this discussion, little did I realize that it was so limited a subject, especially in the New England states.

However, for the benefit of those who are actually exposed to maintenance problems of vacuum filters, and for those who may be indirectly interested, the following information is presented.

In order to have a true picture of this matter, a questionnaire was sent to various sewage treatment plants throughout the country so that a national cross section could be presented. The response to this questionnaire was very gratifying, and before expressing my own views on the subject, I would like to present the information gathered from these various sources. Taking Connecticut first, in the Middletown, Connecticut, sewage plant where an Oliver filter is in operation, Mr. Henry Bauer writes that he has used $^{3}/_{32}$ copper wire since the installation in this plant, with very good results. In using the copper wire it was found that the cloth did not deteriorate as rapidly from the wire bindings. He further writes that at one time a roll of $^{3}/_{32}$ steel wire was tried out, but while in operation and during shut down periods, the wire rusted so badly that filter cloths spoiled before the normal period of time had elapsed.

The Hartford Sewage Treatment Plant was contacted, and Mr. Locke wrote that a 12-gauge stainless steel wire was being used on their vacuum filters, with very good results. An average of 2,000 hours, or three windings was obtained. The reason for discontinuing the use of the stainless steel wire is that after three windings it gets too short for another winding, and it would necessitate the welding of pieces in order to make it longer, and this was found not to be very practical.

At Dearborn, Michigan, Mr. Coburn writes that a 12-gauge steel wire is being used. He writes further that up until two months ago a 14-gauge steel wire was used, with satisfactory results, but due to the scarcity of essential materials a changeover to 12-gauge took place, with hopes that the 12-gauge would result in longer life. Final results on this are not available.

Mr. Baxter of Anderson, Indiana, writes that the Anderson vacuum filters used a 14-gauge steel wire with satisfactory results; however, due to the fact that they had changed over from mechanical filtration to liquid sludge disposal, no definite operating data are available.

* Presented at the Boston meeting on Sept. 22, 1943, of the New England Sewage Works Association.

Mr. Ferrebee of the Milwaukee, Wisconsin, disposal plant writes that they are using a 14-gauge hot galvanized soft temper steel wire, containing a small amount of copper. This wire has replaced a 12-gauge hard drawn copper wire. He states that the service of copper wire was considerably longer, but that the wire usually outlasts the filter cloth, hence resulting in a waste of wire. In order to offset this waste the changeover to 14 gauge steel wire took place.

Mr. Schroepher of the Minneapolis-Saint Paul Sanitary District writes that they used a 14-gauge standard black iron wire for winding filters. The wire lasts as long as the cloth, and the average cloth life in the year 1942 was about 495 hours. Satisfactory results have been obtained in using this type of wire; consequently no plans for a changeover were in order.

Mr. Ellms of the city of Cleveland writes that a 14-gauge galvanized iron wire is being used at the Cleveland plant. Originally, the Oliver filters were fastened with copper wire, but copper was found to be too soft, resulting in breaking and short life span. The galvanized iron wire has performed satisfactorily, and they intend to continue the use of the same.

Last, but not least, in our summary of vacuum filter wire we must consider the New Britain treatment plant. The New Britain plant uses a 12-gauge hard drawn copper bronze wire. On the original installation of the Conkey filters at the plant, a 14-gauge steel wire was used, however, after two weeks' of operation and upon standing idle for one day, the wire left rust lines on the cloth, which eventually resulted in deterioration. The copper bronze wire has performed very satisfactorily, and even though there is a shortage of this critical material, it is believed no changeover will be made.

The wire at the New Britain plant lasts for approximately three windings, or 1,500 hours. It is then discarded, not because of faulty material, but because of the fact that after each winding the ends are cut shorter, making it impractical for use a fourth time. However, since the wire is still useable, it is put aside and shipped to the Enfield Sewage Plant, where a smaller filter is wound with it twice.

Looking over the information on hand one finds that the majority favor some type of steel wire. However a definite rule cannot be set on this matter since each plant is confronted by a set of different conditions, and each operator is faced with the task of determining what type of wire will produce the best results at a minimum of cost.

Further, more time and study should be made by filter manufacturers to determine whether something can be done to improve the present methods employed in keeping filter cloths in place, in order to save labor and materials.

INTERESTING EXTRACTS FROM OPERATION REPORTS

METROPOLITAN DISTRICT, HARTFORD, CONN. (1941 AND 1942)

By George H. Craemer

Engineer-in-Charge

Editor's Note: At the Fall Meeting of the New England Sewage Works Association held at Boston on September 22, 1943, this report brought Mr. Craemer First prize in the annual operation report award competition. It is regretted that space limitations prevent publication of this excellent statistical summary in its entirety.

General

The treatment works serve the municipalities of Hartford, West Hartford and all or portions of Wethersfield, Bloomfield, Windsor and Newington. The plant is designed for 300,000 persons, contributing an average dry weather flow of 39 m.g.d. and a maximum flow of 80 m.g.d. The following treatment units are included:

4 coarse racks, mechanically cleaned.
1 shredder, for reduction of screenings.
4 grit chambers, 60 feet long, mechanically cleaned.
1 Venturi meter, 100 m.g.d. capacity
8 sedimentation tanks, 68 feet by 100 feet by 9 feet deep, affording 2.2 hours detention at the average, design flow, equipped with mechanical sludge and scum collectors.
Aeration in influent channels.
12 sludge and scum pumps.
4 sludge digestion tanks, 50 feet in diameter by 30 feet deep, fixed covers, gas utilized for heating buildings and digesters.
2 mixing and settling units, for elutriation of digested sludge.
2 sludge conditioning tanks.
2 vacuum filters, 350 sq. ft. each.

A plan and flow diagram of the plant is shown in Fig. 1.

Sludge Elutriation

Genter's "counter-current" elutriation process is employed. Two mixing tanks and two sedimentation tanks are used. Digested sludge is mixed in the first mixing tank with water from the top of the second sedimentation tank. The mixture then passes into the first sedimentation tank from the top water overflows, returning through the entire plant. The solid matter settling in the first sedimentation tank is transferred to the second mixing tank and there mixed with three

times its volume of clean water pumped from a group of well points driven into coarse sand underlying the plant. The mixture is settled in the second sedimentation tank and the top water overflows to the first mixing tank, as stated above. The solid matter passes to the conditioning troughs and thence to the vacuum filters.

The mixing tanks are 8 feet square by 10 feet deep and contain a vertical paddle agitator, driven by a 1.5 H.P. variable speed motor. The settling tanks are 85 feet long, 24 feet wide and 10 feet deep with two scraper-collector units per tank. These units are similar in principle to those used on primary sedimentation tanks. No cross collectors are used, however, there being three hoppers at the end of the tank. A withdrawal pipe leads to each hopper. Scraper collectors with 0.5 H.P. motors run about 6 hours per day, 5 days per week. The detention period in the tanks is about 6 hours.

A summary of operation data pertaining to the elutriation process follows:

	1941	1942
Total m.g. sludge to elutriation	4.489	2.378
Total m.g. elutriating water	34.6	31.0
To washing sludge	17.5	13.0
To rewashing, recirculating, etc.	17.1	18.0
Total m.g. elutriated sludge	4.396	2.142
Per cent moisture-elutriated sludge	93.2	91.4
Per cent volatile-elutriated sludge	39.8	38.6

Sludge Cake Analysis

The various constituents of the dewatered sludge cake, expressed as percentages of the dry solids, were as follows:

	Range in Per Cent
Nitrogen (total)	1.7 – 2.0
Phosphoric acid	1.2 – 2.4
Potash	0.2 – 0.5
Volatile (humus)	30.0 – 40.0
Chlorides	0.04 – 0.12
Chloroform soluble grease	5.7 – 6.3
Acid soluble iron	0.4

Filter Cloth Life

The wool filter cloths have given approximately 800 actual working hours each. When removed the cloths had not deteriorated excessively and were still serviceable except that (even with thorough and regular washing with a dilute solution of muriatic acid or trisodium phosphate) the ferric chloride use had increased beyond the economic limit. We are inclined to believe that 800 hours is just about the economic life of the cloth under our conditions.

TABLE 1.—*Summary of Operation Data (Hartford, Conn.)—1941 and 1942*

Item	1941 Average	1942 Average
Plant operated [1] days	314	258.5
Per cent of time	86.0	70.8
Estimated tributary population	210,000	240,000
Sewage flow—m.g.d.	17.8	16.6
Screenings removal—c.f. per m.g.	2.5	2.8
Grit removal—c.f. per m.g.	2.8	2.3
Primary sedimentation period—hrs.	5.2	5.8
Sludge removal—gal. per m.g. sewage	2,530	2,790
Per cent moisture	93.9	92.9
Per cent volatile	66.3	64.8
Lbs. D.S. per capita	0.12	0.20
Lbs. D.S. per m.g. sewage	1,167	1,230
Grease content of scum—p.p.m.	25.5	22.5
5-Day B.O.D., influent—p.p.m.	199	137
Effluent—p.p.m.	138	119
Per cent removal	29.6	36.8
Suspended solids, influent—p.p.m.	137	117
Effluent—p.p.m.	30	25
Per cent removal	76.6	75.1
Sludge digestion temperature—deg. F.	97.3	95.3
Digested sludge—gal. per m.g. sewage	776	569
Per cent moisture	92.2	90.8
Per cent volatile	40.4	36.0
Lbs. D.S. per m.g. sewage	541.1	466.6
Grease content—p.p.m.	8.7	11.8
Gas production—c.f. per capita daily [2]	0.91	0.90
Net B.T.U. value	576	576
Sludge elutriation—washwater ratio	4:1	6:1
Elutriated sludge—per cent moisture	93.2	91.4
Per cent volatile	39.8	38.6
Sludge dewatering—days vacuum filters operated	156	104
Ferric chloride dosage—per cent	2.40	2.41
Filter rate—lbs. per sq. ft. per hr.	7.45	5.61
Sludge cake—lbs. D.S. per m.g. sewage	526	369
Per cent moisture	64.1	59.8
Filtrate pH	6.1	6.1
Operation costs—per m.g. treated	$10.56	$14.90
Per capita for year (adjusted)	$ 0.37	$ 0.42

[1] Operation suspended for hydraulic reasons when Connecticut River stage exceeds 8 feet. Discharge at this stage approximately 20,000 c.f.s.

[2] Per day plant operated.

ROCKVILLE CENTRE, N. Y. (1942)

By C. George Andersen

Superintendent

Description of Plant

The sewerage system and treatment works were built in 1929—designed for a population of 20,000 and a capacity of 2.0 m.g.d. The treatment plant consists of the activated sludge process, separate sludge digestion, gas collection and utilization, and glass-covered

sludge drying beds. The gas is used for heating the digestion tanks. Gas-heated hot water boilers and gas-operated auxiliary engines are the equipment for utilization of the methane gas produced from the decomposition of the organic solids in the digestion tanks.

The activated sludge process was a problem at Rockville Centre, because of "bulking." The plant discharge flowed to natural sand beds and because of the bulking, the sand became clogged creating quite a problem in disposing of the sewage, also nuisance factors developed to such a degree in and around the plant that it became necessary to design and construct additional equipment to cope with the problem. The only outlet or stream to which the plant effluent could discharge was on private property. The problem then, was to provide equipment that would keep the bulking solids out of the stream. In 1933, mechanical vacuum filters were designed, constructed and adopted as an adjunct to the treatment plant.

Three string type vacuum filters were installed using paper pulp as the filter medium. Two of the filters were high submergence for removal of suspended solids in the activated sludge effluent and one low submergence for dewatering the waste pulp, that filter is also used for dewatering raw sludge, using as its filter medium the waste pulp instead of chemicals.

Good Operation Overcomes Bulking

Simultaneously with engineering studies as to the type of equipment necessary to cope with the bulking problem, considerable study was being made by the writer to find a method of preventing bulking. Fortunately, after three years of patience and perservance, methods were found to harness or tame the monster. It is not one factor, but many mechanical procedures along with an understanding of the unit of life, be it aerobic anerobic. It was fortunate that the bulking was controlled, because the filter medium could not take the deluge of solids and the filtrate took on the quality and appearance of raw sewage. First thought would lead one to think that the vacuum filter installation was a failure, but such was not the case. The plant effluent discharged into private streams and ponds and an unusual excellence was demanded of the type of treatment—the sewage flow was twice that in the stream.

Approximately two years ago the plant discharge was diverted to a town road drainage sewer passing by the plant. This drain discharges into a creek two miles below the plant. The water is subjected to the tides, but the changes are limited because of the distance from the active tidal area. The waters are under the jurisdiction of the Nassau County and New York State Health Departments and the Interstate Sanitation Commission. These authorities have set up limitations and requirements as to suspended solids, dissolved oxygen and *B. Coli* organisms to be found in sewage discharged into streams, rivers and bays. The reason and necessity for this is the protection of public health.

In the early part of 1942, reports on eight years of plant operation, observations and reports on the physical conditions and tests on the water in the creek were brought to the attention of the authorities mentioned, with a request, that on the record and plant operation now maintained, the activated sludge effluent be allowed to by-pass the mechanical vacuum filter for a period of time. Should the time come when the limitations and requirements of the named authorities be exceeded, the vacuum filter will again be placed in operation or treatment facilities will have to be installed to meet the requirements.

Upon checking reports and their findings and appreciating the discontinuance of bulking the Nassau County and New York State Health Department and Interstate Sanitation Commission have allowed the trial which went into effect June 1, 1942. I am most happy to report that while suspended solids are slightly higher than in the filtered effluent there is a comfortable margin as to requirements.

Considerable savings have been effected by the control of the activated sludge, especially in stoppage of the filtration. In one month there is a saving of 41,000 k.w., 6.0 million gallons of water, that is reflected in the plant, because all or most of the water used in the filtration plant was returned and treated, reducing the flow by about 200,000 gallons daily; 10 tons of paper or cardboard less is now required, and supplies and parts required will be reduced. The filters will be kept in good running order, however, two operators have been released and will now take part in sewer and plant maintenance for which work extra labor was employed, effecting a saving in labor costs.

A Successful Sewer Maintenance Program

Maintenance of sewers has to our satisfaction become a routine matter. In 1938 we initiated a regular maintenance program in the cleaning, flushing and making of repairs to our sewers and manholes. The program calls for the augeing and flushing of 26 miles of sewer each year thus making a complete tour of the whole system in three years.

The cleaning season starts about March 15, and continues, eight hours daily, five days weekly until June 30. At that time we suspend operations until September 15, when operations start again and continue until November 30. Operating in that way allows manpower for vacations and makes for better efficiency and working conditions, by not laboring under the handicap of extreme high and low temperatures. The labor used for this type of work has been partly extra, and the regularly employed are a part of the plant personnel as stated, taking over vacation relief and making repairs and general maintenance in the winter months.

After the third year of this type of maintenance the results were very gratifying. In 1942 the complaints on sewer stoppages fell off 75 per cent and of the few complaints received only three were in the public sewer the remainder were in the house laterals. We have found in starting the second cycle of sewer cleaning that stoppages are light and

easily cut out. A full size tool is run through each and every sewer when the inspection is made.

Beautification of Grounds

A great amount of time and study has been given to the beautification of the grounds around the tanks, buildings and roads of the treatment plant and pump stations. The ideal situation in a sewage treatment plant is where no nuisance factors exist and a pleasing picture of beauty in the form of green, fresh-looking foliage, trees, shrubs, evergreens with a riot of color obtained by perennial and annual flowers. That, briefly, is the goal for which we are striving.

Have we been successful? To a large degree, we have, because many of our residents do not know of our existence and many others who know the location think of it as a public park, rather than as a sewage treatment plant. Looking back approximately fifteen years to the barren area stripped of trees, and nothing but back-fill, stone, and clay on the surface of the ground at the plant site, one can marvel at the change when viewing pictures of today and yesterday. In the last five years the plant has had a beautiful background in Allen Field. The activities taking place right on the plant grounds are a tribute to the personnel operating the sewage treatment works.

Civilian Defense Functions

At the outset of the year, great was the concern of all of us on the Atlantic Seaboard as to how the war would effect Long Island and especially our area. Faced with realities such as possible bombings, sabotage, shell fire from submarines, and with the heavy air traffic of planes, the possibility of accidents, serious consideration had to be given to the problem.

Our department was made a part of the local civilian defense forces and was assigned to the Utility Division. A group of twenty-five laborers, who could be called mechanics because of their experience in trench and excavation work, are enlisted to assist in event of an emergency.

Before the equipment field was tied up by the war agencies, we had secured a 500 gallon per minute portable pump. The pump is to be used for fire fighting purposes, using sewage should water service fail. The personnel has been drilled in the setting up of the pump at the primary tanks using the sewage for water supply. Also they have attended lectures as to what to do and not to do in emergencies, blackouts, and in the maintenance of their own department. Most essential is contact with the organization at all times and notification on leaving town. Each man has a station to which he reports at the plant. From there the report is forwarded to the nerve center of Civilian Defense that all stations are manned.

We have not become too concerned about guarding our plant and stations. However, gates have been installed and are closed at night. Should there be an outbreak of sabotage, it will, we believe, be directed

TABLE 2.—*Summary of Operation Data (Rockville Centre, New York)*

Item	1942 Average	
Estimated tributary population	17,500	
Sewage flow—average daily	1.99	m.g.d.
Per capita daily	114	gal.
Screenings removal per m.g. sewage	1.2	c.f.
Analytical data:		
5-Day B.O.D.—raw sewage	288	p.p.m.
Primary effluent	160	p.p.m.
Removal	43.5	per cent
Final effluent	41	p.p.m.
Removal	85.8	per cent
Suspended solids—raw sewage	284	p.p.m.
Primary effluent	146	p.p.m.
Removal	48.6	per cent
Final effluent	25	p.p.m.
Removal	91.3	per cent
Primary sedimentation period	54	min.
Skimmings removal—per m.g. sewage	1.0	c.f.
Settleable solids removal	76	per cent
Activated sludge data:		
Aeration period	5.03	hrs.
Applied air per gal. sewage	2.0	c.f.
Aeration power per m.g. sewage	424	kw. hrs.
Mixed liquor solids	740	p.p.m.
Sludge index (Mohlman)	38	
Return sludge rate	3.5	per cent
Return sludge solids	27,013	p.p.m.
Final sedimentation period	2.08	hrs.
Sludge data:		
Primary sludge quantity	1,320	gal. per m.g.
Solids content	3.8	per cent
Volatile content	81	per cent
Waste act. sludge quantity	1,350	gal. per m.g.
Solids content	3.3	per cent
Volatile content	88	per cent
Primary sludge to vac. filters	590	gal. per m.g.
Solids content	2.6	per cent
Volatile content	74	per cent
Filtered sludge solids content	25.0	per cent
Filter yield—per sq. ft. per hr.	0.8	lbs.
Combined sludge to digestion	1,885	gal. per m.g.
Solids content	4.2	per cent
Volatile content	80	per cent
Digested sludge to drying beds	520	gal. per m.g.
Solids content	5.0	per cent
Volatile content	55	per cent
Digestion temperature	85	deg. F.
Digester gas production—per capita	1.0	c.f.
Air dried sludge—solids content	35	per cent
Volatile content	54	per cent
Chlorination data:		
Pre-chlorination dosage	95	lbs. per m.g.
Post-chlorination dosage	37	lbs. per m.g.
Total chlorine applied	132	lbs. per m.g.
Operation costs:		
Per m.g. treated	$59.68	
Per capita per year	$ 2.47	

at power and communication centers and at that time our units will have to be protected.

In event of bombing in the highways our men will be on hand to assist in the disposal of flood waters from ruptured water mains and the repairing of damage to our sewers at which time plans already prepared will be carried out. A co-operative organization has also been set up on a county wide basis.

TIPS AND QUIPS

The opening day shortage of hotel rooms notwithstanding, the Fourth Annual Meeting and Second Wartime Conference of the Federation in Chicago proved to be everything advertised—and then some! A record-breaking registration of 612 profited by the finest technical program as yet arranged and enjoyed the unusual entertainment features which rounded out an eventful week.

From Mayor Kelly's presentation of the keys to Chicago, during which remarks he also keynoted the convention, to the final discussion in the Operator's Forum, it was a meeting crammed brimful with information and edification. No doubt it, the 1943 Wartime Conference established several marks which will be difficult to surpass in the future!

* * *

"Do you have a room as yet?" This phrase might well have been the password to the Conference but it always seemed to be accompanied by a smile. The good sportsmanship demonstrated in the face of the unfortunate situation which developed because of an extension of the convention which preceded that of the Federation, reflected great credit upon our members. The inconvenient but often amusing incidents experienced will not be soon forgotten.

Our own contribution to the humorous anecdotes involves a moderately saturated individual who, at 1:30 a.m., unlocked our door and entered the room after we had retired. We unhesitatingly agreed with his observation "that this is a strange situation" and were not particularly interested to learn that he was "Jenkins from California" as we rapidly herded him into the hall. It seems that Mr. Jenkins had actually been using the rooms during the preceding convention but had been moved out, without his knowledge, upon our arrival.

If you think your plight was sad, think of poor Jenkins!

* * *

The Quarter Century Operator's Club gained two new recruits in Chicago, bringing its total enrollment to 12. Reuben A. Anderson of Muskegon Heights, Michigan and S. L. Tolman, now of the Jeffrey Manufacturing Company were the 1943 neophytes, both having been engaged in sewage treatment works operation in 1917. With the exception of a year in the Army, Mr. Anderson has been in plant operation work continuously since 1917. He now holds the position of superintendent of the Muskegon Heights plant. Mr. Tolman was initiated into the operation field at Mason City, Iowa, in November, 1917.

The Quarter Century Club lost one of its most esteemed members during the year, at the death of Paul Molitor, Sr., of Chatham, New Jersey.

* * *

The address of welcome by Mayor Edward J. Kelly of Chicago was more than an offering of the city's hospitality—it was a well-expressed and fitting introduction to the technical program. When Mr. Kelly deplored the inadequacy of the present 5000 c.f.s. diversion of dilution water from Lake Michigan as "only enough to make the sewage less thick," he spoke with authority, for he was at one time Chief Engineer of the Sanitary District of Chicago!

* * *

We leave the Fourth Annual Meeting of the Federation with a sincere acknowledgment of the efforts of the Management Committee personnel, every one of whom worked diligently and painstakingly to make the conference such an outstanding success.

The Federation is also indebted to Waterworks and Sewerage and its "Doc" Symons for an excellent job on *The Federation Daily*, distributed during the Convention. Symons put in many wee small hours in its preparation.

* * *

From the September, 1943, issue of North Dakota's *Official Bulletin:*

"Conference members will recall that a couple of years ago some slickers were travelling through the State trying to sell a product called 'Hypofermento' guaranteed to be a 'pure sewage culture' that would positively eliminate all future necessity of removing sludge from septic tanks, Imhoff tanks, and the like. For the average small town, about $40.00 to $50.00 worth was all that was necessary to put the tank in tip top shape permanently.

"Conference members regularly attending conventions knew immediately upon being approached that such a product was a fake. The information divulged at the schools at the conventions enable one to determine fraudulent practices from honest practices.

"Now we hear of another racket similar in nature, but not quite so far-fetched. A concern has been travelling through the State attempting to contract for the removal of sludge from Imhoff tanks on a per ton basis. The normal unit price is $5.00 per ton. If this were on a dry solids basis, it might not be such a bad deal, but we strongly suspect that anyone operating under a contract of this nature would charge for all of the water removed and would probably remove as much water as possible. It is entirely conceivable that the average Imhoff tank would run into the neighborhood of $1,000.00 for sludge removal on this basis. Nice racket, eh?"

* * *

Pointing out that only the armed services and war plants with top priority ratings are now eligible to purchase new fire extinguishers, the Safety Research Institute urges that extraordinary care be given such

equipment on hand. The following maintenance and repair instructions are offered:

1. Recharge extinguishers immediately after use and after the interval of time recommended by the manufacturer.
2. Use only recharging supplies and replacement parts obtained from the manufacturer.
3. Follow the instructions on the units closely when recharging all types of extinguishers.
4. Inspect extinguishers at least once a month to make certain they are filled, operative, and have not been tampered with.
5. If an extinguisher is damaged by a blow or fall so that there is a possibility that the shell or seam has been damaged, have the extinguisher tested by the manufacturer or his agent.
6. Do not attempt repairs of damaged extinguishers. Return them to the manufacturer for the skilled work such service demands.
7. Have men on the premises who are familiar with the inspection and recharging of extinguishers, and who understand the correct methods for keeping the equipment ready for instant, efficient use.

* * *

The Galesburg Sanitary District, located in the heart of agricultural Illinois, does not hesitate to apply farming methods in the operation of its sewage treatment plant. Superintendent L. W. Hunt has found light surface scarifying to be beneficial to the trickling filters, at which a surplus of fine filter media has brought about chronic ponding. Use of a horse-drawn harrow for the purpose is shown in Fig. 1.

FIG. 1.—Cultivating a "crop" of filter efficiency at the Galesburg (Illinois) Sanitary District.

* * *

Operators who may have encountered difficulty in maintenance of bearings in revolving distributors at trickling filters will be interested in the conclusions * of John W. Jacobs, Kokomo, Indiana:

* Reported by *Sewage Gas*, September, 1943, published by Indiana State Board of Health.

"After seven years of continuous operation, the rotary distributors are now beginning to cause trouble. One reached the point where it would not rotate properly. On dismantling it was found that the roller bearings were chipped and the bearing plates were worn and damaged to the extent that it was necessary to replace them with new parts.

"The damage and excessive wear on the roller bearings and plates was found on dismantling to be caused primarily by improper lubrication. The grease in the top bearings was so dry that it was necessary to use knives and chisels to remove it. It is believed that the rotary distributors would have given many more useful years of service before it was necessary to replace the bearings had a good grade of oil and grease, one that would function properly during hot and cold weather, been used. It is also necessary to keep the center column plumb and the arms adjusted so that the load is carried evenly all the way around on the bearings."

* * *

To bad that the questionnaire on activated sludge plant operation at Gary, Indiana, was received too late from Superintendent W. W. Mathews to be incorporated in the summary of experience on this topic carried in the September, 1943 issue of the *Journal*.

The Gary plant is among those troubled by iron oxide deposits on the diffuser tubes due to large quantities of ferrous sulfate wastes in the sewage. The tubes have gone as long as 13 months without clogging but, again, have clogged in 30 days. Servicing procedure includes: washing with water and scrub brushes, soaking for 15 to 30 minutes in 40 per cent sulfuric acid, thorough rinse, soaking in Stanisol (a solvent) to remove grease and, finally, painting of the exterior surface with petrolatum.

Superintendent Mathews offers to buy us any hat we select if we can tell him "how to keep iron oxide from depositing on the outside of the diffuser tubes." Our suggestion which was to put the mixed liquor inside of the tubes and apply the air from the outside, seems to be a bit too "simple" to be of real help but out to entitle us to a snood, at least!

Anybody need a new Stetson?

* * *

Would you like to have your plant on display in the Federation's new central office? Our idea of the most appropriate wall decoration is to use especially attractive view of sewage works, enlarged from photographs and framed. At the moment, however, all we have is the idea and we make this as a plea for clear, sharp, glossy prints (8 by 10 inches in size) to have enlarged. Aeroplane views, panoramas and interiors will be most welcome.

We can use at least a dozen pictures. Thanks!

* * *

Editorial

JOURNAL EDITORIAL POLICY

To dispel any questions or doubts in the minds of the readers and users of *This Journal*, your new Editor hastens to point out that Dr. Mohlman will continue to guide and supervise all editorial functions from his new position as Advisory Editor. His present title is not just an honorary one—it means that he will be consulted regarding the make-up of every issue and that his advice and recommendations will be given paramount consideration. The past editorial policies of the *Journal* speak for themselves. With full realization that the real foundation of the Federation lies in the excellence of its official publication, the Board of Control has specifically directed that these policies be continued indefinitely.

In his past three years of close contact with Dr. Mohlman in connection with the production of the *Journal*, the writer has had an unusual opportunity to observe the painstaking care that has gone into its preparation. He has also been in a position to observe the infinite detail that has been Dr. Mohlman's responsibility—the volume of correspondence and the drab chore of proof-reading. Relief of Dr. Mohlman of the onerous detail of his editorial duties was a primary reason for the recent reorganization, although there are several other advantages in having advertising and other functions combined into a central editorial office.

Your new Editor approaches his responsibilities with proper humility as well as a proper regard for the guidance he will require from the experienced hand of the Advisory Editor. It is deemed a rare privilege to have the advantage of such guidance and our readers may rest assured that it will be utilized to the fullest.

Your new Editor further realizes that his vocabulary is inadequate to pay suitable tribute to Dr. Mohlman's past service. Only those who have used and prized the *Journal* for the last fifteen years can appreciate the richness of his contribution to the sewage works field.

W. H. W.

AT YOUR SERVICE

It is full time that the Federation be generally recognized for what it is today—a *service* organization representing a highly specialized, technical field. Until a few years ago, the identity of the Federation as an organization was almost completely buried, with most of us thinking of it (if we thought of it at all) only as a "*Journal.*"

At present, the Federation offers its members and supporters the same *Journal;* a fine annual meeting; the fruits in technical progress and professional welfare of the efforts of many active committees; an

organized representation in matters affecting the entire field, such as in connection with priorities and manpower problems; and finally but not least, a central headquarters for individualized service to its members. In short, "something new has been added".

During the past three years, your Secretary has found keen gratification in extending assistance in response to inquiries by individual members. We are quite proud of our "Service" file which now receives more than a hundred inquiries annually and which stands ready to welcome many more. Technical problems are most common but it has also been possible to render assistance by furnishing statistical data, in personnel placement, in the form of advisory service to individuals desiring to improve their training and education and in several other ways. Naturally, we have not been able to furnish on demand the complete answer to every question, but it has been possible to suggest other sources of information or to refer the problem to some other informed person or agency when our own resources prove inadequate.

This is a plea for you to utilize the new facilities of the Federation to their capacity. You may be assured that every inquiry pertinent to the objectives of the Federation will be welcomed and will bring a courteous response with the very best assistance we can provide.

Your Federation is at your service!

W. H. W.

Proceedings of Member Associations

CANADIAN INSTITUTE ON SEWAGE AND SANITATION

Tenth Annual Convention

Niagara Falls, Ont., October 28–29, 1943

The tenth annual convention of the Canadian Institute on Sewage and Sanitation, held at Niagara Falls, Ontario, on October 28 and 29, 1943, surpassed by all previous meetings. The attendance of 202 considerably exceeded previous registrations, and it was unanimously agreed that this was the best meeting yet held. Interest in the papers and discussions was keen, and the social functions enabled all delegates to mingle freely and discuss their mutual problems.

The program was divided between written papers and guided discussions. Professor R. F. Legget of the University of Toronto gave a paper on "Conservation and Sanitation." This was a thought-provoking survey of the need for conservation of natural resources, with particular reference to sanitation and stream control.

Two papers were given on "Sewage Treatment Practice"; the first on "Standards for Municipal Sewage Treatment Plants" was delivered by A. S. Bedell, Chief of the Bureau of Sewage and Waste Disposal, State Department of Health at Albany, N. Y. In this, the procedure followed in the State of New York was discussed. The second paper on this subject was given by Dr. A. E. Berry of the Provincial Dept. of Health of Ontario, on "Sewage Treatment for Homes and Institutions."

Two papers of considerable interest dealt with the "Design of Storm Sewers." The first outlined "United States Practice," with the author being Dr. W. L. Malcolm, Professor of Civil Engineering at Cornell University. "Canadian Practice" was discussed by David Jack, City Engineer of Kingston, Ont. Both papers contained much information on the practices in use at different centres.

The final paper was given by W. L. Collins of Hamilton, Ont., on "Refuse Collection and Disposal" in that city.

An enthusiastic discussion was held on the subject of "Financing Municipal Works" at which present day practices and post war plans were reviewed.

The new executive of the Institute includes the following: President, R. H. Parsons, City Engineer of Peterborough; Vice-President, R. J. Desmarais, City Engineer of Windsor; Trustees, R. W. Garrett, City Engineer of London, and H. S. Nicklin, City Engineer of Guelph. Past President, on the executive, is B. F. Lamson, City Engineer of St. Catharines. A. E. Berry is Secretary-Treasurer.

An inspection trip was made to the sewage screening plant of Niagara Falls, N. Y., as guests of that city.

Social functions included a dinner and a luncheon. Past President A. S. Bedell of the Federation of Sewage Works Associations represented that organization and brought an interesting account of activities.

Dean C. R. Young of the Faculty of Applied Science, University of Toronto, spoke at the luncheon on "The Place of the Engineer in the Post-War World," in which a most interesting survey of this field was portrayed to the delegates.

The newly organized "Canadian Sanitation Equipment Association" representing manufacturers and distributors contributed much to the success of the meeting by sponsoring a splendid floor show and a "club room" in which the delegates were refreshed and entertained.

FEDERAL ASSOCIATION RECORDS LOSS OF TWO MEMBERS

The loss by death in the past year of Robert W. Kehr and Harry R. Crohurst, respected members of the Federal Sewage Research Association, has been formally noted by that organization in the adoption of the following resolutions:

ROBERT WEBSTER KEHR

It is with deep sorrow and a feeling of irreparable loss that the Federal Sewage Research Association records the death on December 20, 1942, of Robert W. Kehr, Past Assistant Sanitary Engineer of the U. S. Public Health Service. While assigned to the Alaska highway project, Mr. Kehr lost his life in an airplane crash returning from Whitehorse, Yukon Territory, to his home. He was an active member of the Association, having served as its Secretary in 1938 and as its President in 1942. His work was primarily in the field of water pollution research and the practical application of information obtained. His reports, particularly the study of the Scioto River and the observations on the relation between coliforms and enteric pathogens, indicate a deep grasp of the problems of his chosen field.

We shall miss his wisdom, tact, and especially his quiet kindliness and the comfort which his friendly counsel gave us. Therefore, be it

RESOLVED, that the Federal Sewage Research Association expresses its deep regard and appreciation of Mr. Kehr, and be it further

RESOLVED, that the Association extend its deepest sympathy to his widow and family, and that the Secretary be instructed to send a copy of this resolution to Mrs. Kehr.

HARRY ROUNSEVILLE CROHURST

With deep sorrow the Federal Sewage Research Association records the death within the past twelve months of Harry R. Crohurst, Sanitary

Engineer Director, of the U. S. Public Health Service. Mr. Crohurst was one of the original members of the Federal Sewage Research Association, and in 1934 was its President. He was connected with stream pollution research and its practical application for a generation and conducted pollution surveys of many of the most important watercourses of the country. Not the least of these was the recently completed survey and report on the Ohio River and its tributaries. Reports prepared under his direction form a pattern of thoroughness and sound engineering judgment which has been an inspiration to his associates and the sanitary engineering profession. We will miss his wisdom, his tact, his kindliness, the quiet humor characteristic of him, and the friendly counsel which so helped in the solution of our problems. Therefore be it

RESOLVED, that the Federal Sewage Research Association expresses its profound admiration, regard and appreciation for Mr. Crohurst, and be it further

RESOLVED, that the Secretary-Treasurer be instructed to send a copy of this resolution to Mrs. Crohurst.

NEW YORK STATE SEWAGE WORKS ASSOCIATION

Remarks on the occasion of the presentation of the Annual Rating Award to Edward J. Smith, Superintendent of the Niagara Falls Sewage Treatment Plant*

BY A. W. EUSTANCE

Chairman, Rating Committee

This year of 1943 marks the eighth year in which our association has conducted the Annual Rating Contest. During these eight years, a total of 98 reports on the operation of sewage treatment plants has been submitted by operator members of our association. These reports have all been carefully prepared in accordance with the adopted schedule; and they represent, on the part of the operators submitting these reports, an immense amount of work over and above that actually required for the operation of their plants. Because of this additional work entailed in the preparation of these reports, which includes reviewing of past work, methods and results, compiling of data on tests and operation methods, and making of perhaps more laboratory tests than would ordinarily be done, all operators who have participated in the Rating Program by submitting such reports have become better operators by reason of their participation.

It is regretted that only one material award can be made each year, that award being given to the operator whose report, in the judgment of the Rating Committee, is the best for that year. However, honor and recognition are none the less due to all those other operators who have submitted reports; and particularly to those who continue to sub-

* Presented at Spring Meeting of New York State Sewage Works Association, Rochester, N. Y., June 4–5, 1943.

mit reports each year, irrespective of whether or not they succeed in winning the award. To all of those, we extend our thanks and best wishes for the future.

This year, I regret to say that the number of reports submitted has fallen off considerably, even below the number submitted last year. This decrease in the number of reports is, undoubtedly, only temporary and can probably be blamed on the war which has given the operators additional burdens due to shortage of personnel and additional activities due to participation in the war effort.

The rating plan conducted by our association is undertaken solely for the purpose of benefiting the operators, and it does contribute much in this respect in gaining for them well deserved recognition. More effort is needed on the part of our association to continue and supplement this good work, and we individually should do all in our power to promote this work.

In addition to the operator I shall presently name as the recipient of this year's award. Reports were submitted by the following:

C. George Anderson, Rockville Centre
Uhl T. Mann, Cortland
William Edwards, Gowanda State Hospital
Harry M. Monsell, Greenport
Charles G. Hart, Ley Creek Sewage Treatment Works

To each of you, may I extend my thanks and the thanks of our association? In each instance, the Rating Committee will write to the official boards of the municipalities or institutions represented by these operators, commending these operators for their reports and otherwise thanking them for their cooperation.

It now becomes my duty, and a very pleasant one, to present the 1943 Annual Rating Award to the operator judged by the Rating Committee to be the winner for this year. The competition was exceedingly close; but after a careful study and review of each report, the vote of the committee was unanimous in granting the award to the operator of the Niagara Falls sewage treatment plant.

The operator of this plant, as you all know, is Edward J. Smith, the President of our association, and it is to be noted that this is the first occasion where a president during his term of office has won this award.

Mr. Smith, in behalf of the association, this award is made to you in recognition of the excellence of your report on the operation of the Niagara Falls sewage treatment plant.

MEMBER ASSOCIATION MEETINGS

Association	*Place*	*Date*
New England	Springfield, Massachusetts (Hotel Kimball)	May 17, 1944
New Jersey	Trenton, N. J. (Stacy-Trent Hotel)	March 23–24, 1944

Federation Affairs

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

MINUTES OF MEETING OF 1943 BOARD OF CONTROL

Hotel Sherman, Chicago, Illinois, October 20, 1943

The Annual Meeting of the 1943 Board of Control of the Federation of Sewage Works Associations was called to order by President George J. Schroepfer, in the Grey Room of the Hotel Sherman, Chicago at 6:35 p.m., October 20, 1943.

Roll call indicated the following representation:

PRESENT IN PERSON

Affiliate or Office Represented	*Represented By*
President	G. J. Schroepfer
Past President	A. S. Bedell
Treasurer	W. W. DeBerard
California Sewage Works Ass'n	W. A. Allen
Central States Sewage Works Ass'n	Major B. A. Poole
Georgia Water and Sewage Ass'n	Van P. Enloe
Missouri Water and Sewerage Conf.	W. Q. Kehr
New England Sewage Works Ass'n	J. H. Brooks, Jr.
Ohio Sewage Works Ass'n	C. D. McGuire
Canadian Institute on Sewage and Sanitation	Dr. A. E. Berry
Director-at-Large	W. J. Orchard
Water and Sewage Works Manufacturers Ass'n	D. S. McAfee
Water and Sewage Works Manufacturers Ass'n	W. B. Marshall
Publications Committee	F. W. Gilcreas
Sewage Works Practice Committee	Morris M. Cohn

PRESENT IN PERSON, ACTING BY PROXY

Affiliate or Office Represented	*Represented By*
Argentine Soc. Engrs., Sanitary Engr. Div.	F. W. Mohlman (For E. B. Besslievre)
Arizona Water and Sewage Works Ass'n	W. H. Wisely (For P. J. Martin)
Dakota Water and Sewage Works Conf.	K. C. Lauster (For W. W. Towne)
Federal Sewage Research Ass'n	C. C. Ruchhoft (For J. K. Hoskins)
Michigan Sewage Works Ass'n	C. P. Witcher (For N. G. Damoose)
New Jersey Sewage Works Ass'n	W. H. Wisely (For E. P. Molitor)
New York State Sewage Works Ass'n	L. H. Enslow (For C. G. Andersen)
Pennsylvania Sewage Works Ass'n	C. A. Emerson (For F. S. Friel)
Water and Sewage Works Manufacturers Ass'n	W. B. Marshall (For K. M. Mann)

President Schroepfer declared a quorum to be present.

By consent, reading of the minutes of the meetings of the Board of Control held at Cleveland on October 24, 1942 was dispensed with, these minutes as published in the January, 1943 issue of SEWAGE WORKS JOURNAL being ordered approved.

President Schroepfer presented the following report:

"Without detracting in any way from the reports of the Secretary and Treasurer which will follow, it is a pleasure to report to the Board that during the past year the membership of the Federation and its financial condition have improved

materially with an increase in membership to a total of more than 2,600, and with an increase in the assets of the Federation to more than $20,000. Your President takes no credit, but rather wishes to pass this on to the other officers of the Federation, and particularly to the Executive Secretary, who in a large measure is responsible for the growth and success of the Federation during the past year.

"Your President also wishes to record with appreciation the co-operation and sincere interest in the welfare of the Federation on the part of the Executive Committee and the Chairman and members of the many other committees of the Federation. He particularly wishes to express his appreciation to the past presidents, Messrs. Emerson and Bedell, who throughout the year have worked untiringly to promote the welfare of the Federation. With such a fine spirit of co-operation, and if the recommendations for expansion of the Secretary's office, made by a special committee, and concurred in by your Executive Committee, are approved, your President is certain that the Federation will advance to a much more enviable position from the financial and membership standpoint, but particularly from the viewpoint of service it will render to its membership.

"It was a real honor and a pleasure for your President to have been placed in position to be of service during the past year."

Secretary Wisely commented briefly on his prepared report for the year ended September 30, 1943, copies having been distributed to all members of the Board prior to the meeting. By motion, regularly seconded and carried, the report was accepted with commendation to the Secretary.

Treasurer DeBerard read his report for the year ended September 30, 1943, which report stated that the unencumbered balances in the depositories of the Federation on September 30, 1943 totalled $16,110.64, of which $7,751.64 is on deposit in the Continental-Illinois National Bank and Trust Company of Chicago and $8,359.00 is in Busey's State Bank of Urbana. The report pointed out that these balances substantiate the financial statements contained in the Secretary's report. He reported further that $7,000 of Federation funds had been invested, during 1943, in Series G, U. S. Savings Bonds bearing 2½ per cent interest. It was regularly moved, seconded and carried that the Treasurer's report be accepted subject to the annual audit and that the Executive Secretary be instructed to arrange for such audit to be performed as in the past.

Editor Mohlman presented a statistical summary of the editorial content of the JOURNAL for the past year, with a comparison showing trends in recent years. Commenting thereon, Dr. Mohlman urged that continuing emphasis be accorded fundamental research articles and that every effort be made to increase the space devoted to industrial waste problems and to the medical aspects of sewage disposal, since such material constitutes the strongest value of the JOURNAL as a reference. In recommending expansion of the scientific functions of the Federation, Dr. Mohlman suggested that such service notices as those relating to priorities, personnel problems, etc. be disseminated by separate mailing rather than by publication in the JOURNAL. It was the sense of the meeting that Dr. Mohlman's proven editorial policies should be continued in the future. In appreciation of his 15 years of unselfish and devoted service as Editor of the JOURNAL, Dr. Mohlman was accorded a rising vote of thanks.

The report of the Executive Committee was presented by President Schroepfer and action was taken on the following recommendations:

1. That the report of the Meeting Place Committee, presented herewith, be adopted:

"Following consideration of several invitations, the Meeting Place Committee recommends that the 1944 Annual Meeting of the Federation be held at Pittsburgh, Pennsylvania, subject to the completion of satisfactory hotel arrangements. The Committee expresses due appreciation for the cordial invitations received from Toronto and St. Paul."

It was regularly moved, seconded and carried that adoption of the above item be recommended to the 1944 Board of Control with final hotel arrangements to be submitted to the Executive Committee for approval.

2. That the recommendations of the Special Committee on Expansion of the Secretarial office (listed herewith) be adopted:

"(1) The procurement and equipment of a suitable office in the Urbana-Champaign area.

"(2) The appointment of W. H. Wisely as full-time Secretary, Editor and Advertising Manager at a salary of $6,500 per year.

"(3) The retention of Dr. F. W. Mohlman as Advisory Editor for general supervision of editorial matter in SEWAGE WORKS JOURNAL and as Editorial Advisor to the Publications and the Sewage Works Practice Committees, without salary, as requested by him.

"(4) Increase of the office staff by not more than two additional employees."

By motion, regularly seconded and carried, the above recommendation of the Executive Committee was approved.

It was further moved, seconded and carried that Dr. Mohlman be reimbursed for any out-of-pocket expense incurred in his duties as Advisory Editor.

3. That the 1944 budget be prepared by the Financial Advisory Committee (presented herewith) be approved:

Receipts	
Dues (all classes)	$ 9,000.00
Non-member Subscriptions	1,500.00
Advertising (Net)	12,000.00
Sale of Publications (Net)	300.00
Manufacturers Association	5,000.00
Miscellaneous	250.00
Total Receipts	$28,050.00
Expenses	
JOURNAL Printing and Mailing	$12,000.00
Editorial Expense	1,000.00
Executive Secretary—Salary	6,500.00
Office Salaries	4,500.00
Office Rent	900.00
Office Expense	900.00
Travel Expense	700.00
Officers' Travel Expense	400.00
Committee Expense	400.00
Convention Expense	300.00
Contingencies	450.00
Total Expenses	$28,050.00

A motion was made, seconded and carried that adoption of the above budget for the year 1944 be recommended to the 1944 Board of Control.

4. That, conforming to past precedent, the Financial Advisory Committee, consisting of the President, Past President and W. J. Orchard as Chairman, be continued.

Continuation of the Financial Advisory Committee, constituted as stated, was recommended to the 1944 Board of Control by motion, regularly seconded and carried.

5. That a Membership Committee be included in the list of Federation committees, and that the President be authorized to appoint such a committee.

Following discussion of this recommendation, a motion was made that a Membership Committee be created, such Committee to consist of the Executive Secretary of the Federation as Chairman and a representative to be appointed by every Member Association affiliated with the Federation. The motion was duly seconded and carried.

At this point, President Schroepfer announced that, due to the interest of an anonymous donor, two $100 denomination, Series E, U. S. War Bonds were being made available as membership prizes for a contest to be conducted from October 1, 1943 to September 30, 1944. The prizes are to be awarded to (1) the individual designated by the Member Association enrolling the greatest number of new members during the year as having been most responsible for such enrollment and (2) the individual designated by the Member Association showing the greatest percentage increase in membership for the period of the contest as having contributed most to such growth. It was the sense of the meeting that these membership prizes be given publicity as soon as possible.

A motion was made, seconded and carried that this Board recommend to the 1944 Board of Control that all past presidents of the Federation be designated as advisory members of the Executive Committee.

The report of the General Policy Committee was presented by Chairman Bedell. The first recommendation of the Committee was as follows:

> "*Limitation of Member Association Territory.* This is Item 5 in last year's report and was discussed at considerable length at that time. Your Committee feels that the problem has two phases: namely, policy and practical application. The function of this Committee is largely to consider and recommend policies, leaving to existing or new committees the details of the practical application.
>
> "In the present problem, your Committee is strongly of the opinion that it is a proper function of the Federation to limit the territory of Member Associations. The method of securing such limitations should not be arbitrary or dictatorial, since the chief aims of such limitation are (1) to secure natural divisions of territory looking toward future developments as well as meeting present needs and (2) to foster the development of strong, healthy local associations, which will become dynamic forces in the Federation.
>
> "A review of the list of Member Associations (see page 149, SEWAGE WORKS JOURNAL, January, 1943) shows clearly many groups are too small to function properly. Under proper and diplomatic guidance, these smaller groups might well become nuclei of larger groups in contiguous territories.
>
> "Your Committee, therefore, recommends that the policy of 'Limitation of Member Association Territory by the Federation' be adopted and that the problem be referred to the Organization Committee for study and report."

It was moved, seconded and carried that this statement of policy be accepted and referred to the Organization Committee for report at the next Annual Meeting to the 1944 Board of Control.

The second recommendation of the General Policy Committee follows:

> "(*A*) Individuals residing in a locality included in the territory embraced by an existing Member Association shall become members of that Association. If the residence and the place of business of a prospective member are located in the territories of different Member Associations, he may become a member of either Association, and like situated present members may continue membership in either of such Associations.
>
> "(*B*) Individuals residing in a locality which is not included in the territory embraced by an existing Member Association may become members of an accessible Member Association.
>
> "Whenever a new Member Association is formed or the territory of an existing Member Association is extended so as to include in its territory the locality in which such member resides or has his place of business, he shall transfer his membership to that Member Association at the expiration of the period for which his dues are paid.
>
> "(*C*) There shall be no restriction on the number of Member Associations which an individual may join provided he adheres to the principles set forth in (*A*) and (*B*) and provided he pays whatever dues his several memberships entail. (A number of associations provide for a reduction in dues for *dual* members since they receive the JOURNAL through their basic membership.)"

It was moved, seconded and carried that this policy be approved as a recommendation to all Member Associations excepting the Federal Sewage Research Association to amend their By-Laws to conform to the above principles.

The third recommendation of the General Policy Committee pertained to the functioning of this Committee with other Federation constitutional and special committees. It was moved, seconded and carried that the Executive Secretary be made an ex-officio member of the General Policy Committee and that all other sections of this recommendation be laid on the table.

The report of the Publications Committee was presented by title, since copies had been furnished all members of the Board prior to the meeting. The report described the activities of the Committee in regard to arrangement of the program for the 1943 Wartime Conference and the negotiations carried on with the A.P.H.A. and A.W.W.A. in connection with publication of the Ninth Edition of "Standard Methods for the Examination of Water and Sewage." There were no recommendations. The report was accepted by motion, regularly seconded and carried.

The report of the Organization Committee was presented by title, copies having been furnished each member of the Board prior to the meeting. Progress by the Committee in reviewing the constitutions and by-laws of Member Associations was reported. The report was accepted by motion, regularly seconded and carried.

The report of the Sewage Works Practice Committee, copies of which had previously been furnished each member of the Board was presented by title. Progress made in developing Manuals of Practice on (1) The Use of Sewage Sludge for Fertilizing Purposes, (2) Air Diffusion, (3) Occupational Health Hazards in Operation of Sewerage Systems, and (4) Maintenance of Sewers and Sewer Appurtenances was reported and outlines of the proposed manuals were presented. The report was accepted with commendation to the Committee, by motion, seconded and carried.

Copies having been distributed to members of the Board prior to the meeting, the report of the Research Committee was presented by title. The work of the Committee in preparing its annual review of the literature and in the new venture of conducting a survey of research projects currently being studied as well as those problems in need of study was described. The report was accepted with thanks and commendation to Chairman Rudolfs and the Committee for the splendid service rendered.

The report of the Committee on Standard Methods of Sewage Analysis was presented by title, copies having been distributed prior to the meeting. The report stated that the Committee had compiled copy for the sewage analysis portion of the Ninth Edition of "Standard Methods" and that said copy had been submitted to the Joint Editorial Board. A recommendation was made that this Committee be made a permanent one with constitutional authority in order that new developments in analytical methods may be constantly studied. It was further recommended that the present Committee be discharged with thanks. By motion, regularly seconded and carried, the recommendations of the Standard Methods Committee were laid on the table for action by the 1944 Board of Control.

There was no new report by the Operation Reports Committee, its 1943 report having been referred to the Sewage Works Practice Committee for review and recommendation. Chairman Cohn reported on the review of the 1943 Operation Reports Committee report as follows:

1. The Sewage Works Practice Committee reached no unanimous opinion on the report as submitted to the Committee, a tie vote having been recorded.
2. It is recommended that operation report awards be deferred for the duration.
3. That appreciation and thanks be extended the 1943 Operation Reports Committee for the splendid work done.

Following lenghty discussion, it was moved, seconded and carried that the original report of the Operation Reports Committee be referred back to that Committee with instructions to continue its studies.

There being no report from the Publicity and Public Relations Committee, Mr. Emerson suggested that the need for this Committee might be obviated by the proposed new duties of the Executive Secretary. It was moved, seconded and carried that the matter be referred to the 1944 Board of Control.

The report of the Operators Qualifications Committee, copies of which had been distributed prior to the meeting, was presented by title. It was moved, seconded and carried that the report be referred to the General Policy Committee to review and report back to the 1944 Board in its meeting of October 23, 1943.

The report of the Committee on Honorary Membership was presented by Committee Chairman C. A. Emerson. The Committee unanimously recommended election to the grade of Honorary Member, Charles Gilman Hyde of the California Sewage Works Association and Howard Eugene Moses of the Pennsylvania Sewage Works Association, both of whom had been properly nominated by the executive bodies of their respective Member Associations. Messrs. Hyde and Moses were elected to the grade of Honorary Member by motion, regularly seconded and carried.

Mr. Brooks reported further that the plans of the New England Sewage Works Association to nominate the late Robert Spurr Weston for Honorary Membership had been suspended by his untimely death. It was the sense of the meeting that, in tribute to Mr. Weston, the intent of the New England Sewage Works Association to accord him this honor be recorded in these minutes.

The report of the Awards Committee was read by the Secretary. The report outlined the mechanics of the procedures for assigning the various awards and recommended that the 1943 awards be approved as follows:

Award	*Recipient*
Harrison Prescott Eddy (Research)	Harry Willard Gehm
Charles Alvin Emerson (Federation Service)	Floyd William Mohlman
George Bradley Gascoigne (Operation)	Kerwin L. Mick
Kenneth Allen (Central States)	William Homer Wisely
Kenneth Allen (Iowa)	Alfred Henry Wieters
Kenneth Allen (Michigan)	Edward F. Eldridge
Kenneth Allen (North Carolina)	Robert S. Phillips

The Committee pointed out further that four Member Associations eligible to nominate for the Kenneth Allen Award this year had not been able to make a nomination in the short time available and recommended that 1943 awards be granted the nominees from these Associations upon submission of the names to the Executive Secretary. By motion, seconded and unanimously carried, the Board approved the awards as listed above with instructions to the Executive Secretary to prepare and present 1943 Kenneth Allen Awards to the individuals nominated by the Sewage Section, Texas Division, S.W.W.A., New Jersey Sewage Works Association, Pacific Northwest Sewage Works Association and Institute of Sewage Purification (England).

It was moved, seconded and carried that the 1943 Awards Committee be discharged with thanks, with a recommendation to the 1944 Board that it be reappointed in token of the outstanding service rendered.

The Secretary presented the applications of the following companies for Associate Membership:

Graver Tank and Manufacturing Company
Automatic Control Company
Clay Products Association
Iowa Valve Company
W. S. Dickey Clay Manufacturing Company

It was moved, seconded and carried that the above applications be approved.

For the benefit of the record, the Secretary reported the results of the letter ballot closed May 1, 1943, by which the Associate Member applications of the following companies were approved by a vote of 29 ayes of a total of 29 ballots returned:

Omega Machine Company
Green Bay Foundry and Machine Company
Everson Manufacturing Company
Eimco Corporation
Gale Oil Separator Company

The Secretary presented a communication received from Secretary H. E. Jordan of the Water and Sewage Works Development Committee, of which the Federation is a joint sponsor, which communication advised that the Federation's share of budgeted expenses of the Committee was $1,180. It was moved, seconded and carried that the sum of $1,180 be appropriated from surplus as a non-recurring expense item, for payment toward the expenses of the Water and Sewage Works Development Committee as requested.

To expedite the handling of business by the Board of Control at the next Annual Meeting, it was moved, seconded and carried that the Annual Meeting of the 1944 Board of Control in October, 1944 be held as a luncheon at 12:30 p.m. on the day preceding the opening of the 1944 Convention of the Federation, and kept in session until all business is concluded.

President Schroepfer issued a call for a meeting of the Directors representing all Member Associations to sit as the Election Committee in a session immediately following adjournment of this meeting.

The meeting adjourned *sine die* at 10:10 p.m

Approved:

G. J. Schroepfer, *President* W. H. Wisely, *Secretary*

MINUTES OF MEETING OF 1943 ELECTION COMMITTEE

Hotel Sherman, Chicago, Illinois, October 10, 1943

The called meeting of the 1943 Election Committee of the Federation of Sewage Works Associations was called to order at 10:12 p.m., October 20, 1943, in the Grey Room of the Hotel Sherman, Chicago, Illinois. President George J. Schroepfer presiding.

Roll call of Directors follows:

Present in Person

Member Association Represented	*Director*
California Sewage Works Ass'n	W. A. Allen
Missouri Water and Sewerage Conf.	W. Q. Kehr
New England Sewage Works Ass'n	J. H. Brooks, Jr.
Ohio Sewage Works Conf.	C. D. McGuire
Canadian Institute on Sewage and Sanitation	Dr. A. E. Berry

Present in Person, Acting by Proxy

Member Association Represented	*Director*
Arizona Sewage and Water Works Ass'n	D. S. McAfee (For P. J. Martin)
Central States Sewage Works Ass'n	W. J. Orchard (For B. A. Poole)
Dakota Water and Sewerage Works Conf.	K. C. Lauster (For W. W. Towne)
Federal Sewage Research Ass'n	C. C. Ruchhoft (For J. K. Hoskins)
Michigan Sewage Works Ass'n	C. P. Witcher (For N. G. Damoose)
New Jersey Sewage Works Ass'n	M. M. Cohn (For E. P. Molitor)
New York State Sewage Works Ass'n	L. H. Enslow (For C. G. Andersen)
Pennsylvania Sewage Works Ass'n	C. A. Emerson (For F. S. Friel)
Sanitary Engr. Div. Argentina Soc. Engrs.	W. B. Marshall (For E. B. Besselievre)

The above representation constituted a quorum.

Upon call for nominations for the office of President, A. M. Rawn (California) was nominated and a motion to close the nominations was duly seconded and carried. By *viva voce* vote, the election of Mr. Rawn to the office of President was confirmed and so declared.

Dr. A. E. Berry (Canadian Institute) was nominated to the office of Vice-President in response to a call for nominations to that office. There being no further nominations,

a motion was made, seconded and carried that the nominations be closed. The election of Dr. Berry as Vice-President was confirmed by *viva voce* vote and so declared.

In response to a call for nominations to the office of Treasurer, the name of W. W. DeBerard (Central States) was offered and the nominations closed by passage of a regularly seconded motion. By *viva voce* vote, the election of Mr. DeBerard to the office of Treasurer was confirmed and so declared.

Upon call for nominations to the office of Director-at-Large, with term expiring in October, 1946, Mr. C. A. Emerson (Honorary, Pennsylvania) was nominated, after which the nominations were closed by motion regularly seconded and carried. His election to the office of Director-at-Large was confirmed by *viva voce* vote and so declared.

Upon motion duly made, seconded and carried, the meeting adjourned *sine die* at 10:26 p.m.

Approved:

G. J. SCHROEPFER, *President* W. H. WISELY, *Secretary*

MINUTES OF MEETING OF 1944 BOARD OF CONTROL

Hotel Sherman, Chicago, Illinois, October 23, 1943

The first meeting of the 1944 Board of Control of the Federation of Sewage Works Associations was called to order at 1:25 p.m., October 23, 1943 in the Grey Room of the Hotel Sherman, Chicago, Illinois. The meeting was called to order by President George J. Schroepfer.

Roll call indicated the following representation:

PRESENT IN PERSON

Office or Affiliate Represented	*Represented By*
President	G. J. Schroepfer
President-elect	A. M. Rawn
Vice-President	Dr. A. E. Berry
Treasurer	W. W. DeBerard
California Sewage Works Ass'n	W. A. Allen
Central States Sewage Works Ass'n	Major B. A. Poole
Dakota Water and Sewage Works Conf.	K. C. Lauster
Georgia Water and Sewage Ass'n	V. P. Enloe
Missouri Water and Sewerage Conf.	W. Q. Kehr
New England Sewage Works Ass'n	J. H. Brooks, Jr.
New York State Sewage Works Ass'n	C. G. Andersen
Ohio Sewage Works Conf.	C. D. McGuire
Director-at-Large	C. A. Emerson
Director-at-Large	A. H. Niles
Director-at-Large	W. J. Orchard
Water and Sewage Works Manufacturers Ass'n	L. H. Enslow
Water and Sewage Works Manufacturers Ass'n	Karl M. Mann
Organization Committee	Earnest Boyce
Publications Committee	F. W. Gilcreas
Sewage Works Practice Committee	M. M. Cohn

PRESENT IN PERSON, ACTING BY PROXY

Office of Affiliate Represented	*Represented By*
Arizona Sewage and Waterworks Ass'n	F. W. Mohlman (For P. J. Martin)
Florida Sewage Works Ass'n	J. B. Miller (For Joe Williamson, Jr.)
Federal Sewage Research Ass'n	C. C. Ruchhoft (For J. K. Hoskins)
New Jersey Sewage Works Ass'n	H. Van DerVliet (For E. P. Molitor)
Pacific Northwest Sewage Works Ass'n	B. Morrow (For C. D. Forsbeck)
Pennsylvania Sewage Works Ass'n	H. E. Moses (For F. S. Friel)

Rocky Mountain Sewage Works Ass'n	D. E. Kepner (For L. O. Williams)
Sanitary Engr. Div., Argentina Soc. Engrs.	A. S. Bedell (For E. B. Besselievre)
Water and Sewage Works Manufacturers Ass'n	R. J. Steindorf (For W. B. Marshall)

The above representation constituted a quorum. Secretary W. H. Wisely was also present.

The Secretary presented the report of the Election Committee, which had stated the following officers to have been elected for the terms indicated: A. M. Rawn, President; Dr. A. E. Berry, Vice-President; W. W. DeBerard, Treasurer (all to serve until October, 1944); C. A. Emerson, Director-at-Large (to serve until October, 1946).

Mr. Schroepfer relinquished the chair to President-elect A. M. Rawn, who presided over the remainder of the meeting.

President Rawn commented on the good work of his predecessors and pointed out that the Federation is now in an enviable position to afford service to the field. He requested the full co-operation of the officers and Board of Control in approaching the new and expanded responsibilities of the organization.

A motion was made, seconded and carried to adopt the recommendation of the 1943 Board of Control that the executive offices of the Federation be expanded in the Urbana-Champaign, Illinois area and that W. H. Wisely be appointed for a two-year term as Executive Secretary, Editor and Advertising Manager. It was recognized that the conflict in terms of office of the Secretary and Editor, as set forth in the By-Laws, would not be significant under the above arrangement.

The action of the 1943 Board of Control in appointing Dr. F. W. Mohlman as Advisory Editor of SEWAGE WORKS JOURNAL, without compensation except for reimbursement of out-of-pocket expenses, was approved by motion, regularly seconded and carried.

The Secretary presented, in behalf of the Convention Management Committee, a preliminary report on registration and finances of the Fourth Annual Convention. Total registration was 612, comprising 549 men and 63 ladies. Receipts from registration and sale of tickets totalled about $3,800 with expenses totalling approximately $3,350, leaving an apparent surplus of about $450. It was moved, seconded and carried that the report be received and that the Chairman of the Local Finance Committee be instructed to file his final report with the Chairman of the Financial Advisory Committee of the Federation.

A motion was made, seconded and carried that the 1944 budget, as recommended by the 1943 Board of Control, be adopted.

Mr. Cohn requested that the record show that the various actions by the 1943 Board on matters ordinarily given attention by the incoming Board of Control were actuated only by a desire to give an official status to these matters and enable them to be announced to the membership-at-large during the course of the Convention.

The report of the War Services Committee, received by the Secretary too late for presentation to the 1943 Board, was read. The report reviewed the activity of the Committee in co-operating with the Office of Civilian Defense and described the directive being distributed to local Citizens Defense Corps units to govern post-disaster reconstruction of public service facilities, including sewage works. Reference was also made to the progress made in priorities administration for sewage works, for which the services of President Rawn were commended highly, and to the clarification of the manpower situation during the past year. The report contained no recommendations and was accepted as a statement of progress, by motion, seconded and carried.

Chairman Bedell of the General Policy Committee was called upon to report on the Operators Qualifications Committee report which had been referred to the General Policy Committee by the 1943 Board. His statement follows:

> "In accordance with the action taken at the meeting of the Board of Control on October 20, 1943, the General Policy Committee has considered the above report and presents the following report on its deliberations Thursday evening, October 21.
>
> "Three members of the General Policy Committee, Messrs. Moses, Enloe and Bedell, conferred jointly with Morris Cohn, Chairman of the Sewage Works

Practice Committee, A. E. Berry, member of the Executive Committee, W. A. Allen, Director from California, Messrs. Piatt and R. S. Phillips from North Carolina, F. W. Gilcreas, Chairman of the Publications Committee and L. W. Van Kleeck, Chairman of the Committee on Qualifications of Sewage Treatment Plant Operators.

"The entire report was reviewed, the existing situation in North Carolina, California, Connecticut and New York was discussed and certain revisions, mostly of a minor nature, were recommended to Mr. Van Kleeck. The latter concurred heartily in all the suggested revisions stating he felt his Committee would also concur.

"Mr. Van Kleeck requested, therefore, that the report as revised be submitted to the Board of Control for final consideration.*

"The General Policy Committee as represented and augmented by those present at this meeting states that in its opinion the aforesaid report as revised is sound in principle and that the Committee standards and the various items recommended in the report are desirable and in the interest of the advancement of sewage treatment. Your Committee recommends, therefore, that the Board of Control give favorable consideration to the adoption of this report.

"Your particular attention is called to Item 7, Section I and to Section X.

"The proposed revisions as accepted by the Committee on Qualifications of Sewage Treatment Plant Operators are as follows:" *

It was moved, seconded and carried that the report of the 1943 Operators Qualifications Committee, as amended in the General Policy Committee, be accepted with a recommendation to the Program Committee that arrangement be made for an open forum discussion on the report at the next Annual Meeting and that the report be published in an early issue of the JOURNAL under a statement that opportunity for discussion will be afforded in said forum.

Past President Schroepfer presented a tentative schedule of constitutional and special committees which had been prepared for assistance and guidance to the new officers and Board. His motion to approve the following appointments to the 1944 Executive Committee was seconded and carried:

1944 Executive Committee

A. M. Rawn,† *Chairman* (California)
W. B. Marshall (Manufacturers)
J. K. Hoskins (Federal)
A. H. Wieters † (Iowa)
V. P. Enlow † (Georgia)

It was moved, seconded and carried that the recommendation of the 1943 Board that Past Presidents Schroepfer, Bedell and Emerson serve as advisory, non-voting members of the Executive Committee, be approved.

Following discussion and minor amendment of the tentative schedule of 1944 constitutional committee appointments, these were approved as follows, by motion, regularly seconded and carried:

General Policy Committee (Latest living Past President as Chairman, three Directors, three members-at-large, three of total to be operators—3-year terms)

G. J. Schroepfer,† *Chairman*
R. E. Fuhrman (Federal, Opr.), Member-at-Large
S. C. Probasco (New Jersey, Opr.), Member-at-Large
A. S. Bedell † (New York), Member-at-Large
E. P. Molitor † (New Jersey, Opr.), Director
J. H. Brooks † (New England, Opr.), Director
J. Williamson, Jr.† (Florida), Director

* Report as amended in the General Policy Committee is published in full in the November 1943 issue of the *Journal*.

† New member of committe

Publication Committee (Editor and at least 4 Members-at-Large)

F. W. Gilcreas, *Chairman* (New England)
F. W. Mohlman, *Advisory Editor* (Central States)
W. H. Wisely,* *Editor* (Central States)
Rolf Eliassen (New York)
R. S. Phillips (No. Carolina)
E. W. Steel (Texas)
Carl Green (Pacific Northwest)
F. M. Veatch, Jr. (Kansas)
F. S. Friel (Pennsylvania)
C. C. Larson (Central States)

Organization Committee (At least 3 Members-at-Large)

Earnest Boyce, *Chairman* (Kansas)
C. R. Compton * (California)
R. H. Suttie (New England)

Sewage Works Practice Committee (Editor and at least 4 Members-at-Large)

Morris M. Cohn, *Chairman* (New York)
F. W. Mohlman, *Advisory Editor* (Central States)
W. H. Wisely,* *Editor* (Central States)
C. E. Keefer (Maryland-Delaware)
John Brooks (New England)
G. P. Edwards (New York)
Harold F. Gray (California)
J. J. Wirts (Ohio)
John R. Downes (New Jersey)
A. H. Niles (Ohio)
L. W. Van Kleeck * (New England)

Research Committee (At least 4 Members-at-Large appointed by Chairman, President concurring)

W. Rudolfs, *Chairman* (New Jersey)

It was moved, seconded and carried that the following special committee appointments be received from the President:

Nomenclature Committee (3 members serving with similar committees of the A.S.C.E. and A.P.H.A.)

C. J. Velz, *Chairman* (New York)
F. W. Jones (Ohio)
C. E. Keefer (Maryland-Delaware)

Standard Methods for the Examination of Sewage Committee

W. D. Hatfield, *Chairman* (Central States)
George Symons (New York)
S. E. Coburn (New England)
A. J. Fischer (New York)
G. P. Edwards (New York)
E. W. Moore (New England)
D. E. Bloodgood (Central States)
F. W. Gilcreas (New England)
E. F. Hurwitz (Central States)
Keeno Fraschina * (California)
W. S. Mahlie (Texas)
M. Starr Nichols (Central States)
Richard Pomeroy (California)
C. C. Ruchhoft (Federal)
Willem Rudolfs (New Jersey)

Awards Committee

C. G. Hyde, *Chairman* (California)
E. S. Chase (New England)
G. P. Edwards (New York)
C. C. Larson (Central States)
L. F. Warrick * (Central States)

Operating Report Committee

H. E. Babbitt, *Chairman* (Central States)
W. A. Allen (California)
W. F. Shephard * (Michigan)

Publicity and Public Relations Committee

N. S. Nussbaumer, *Chairman* (New York)
D. E. Bloodgood (Central States)
H. R. Hall (Maryland-Delaware)
W. L. McFaul (Canada)
Prof. E. L. Waterman (Iowa)
Prof. E. G. Tyler (Pacific Northwest)

Operators' Qualifications Committee

L. W. Van Kleeck, *Chairman* (New England)
P. J. Kleiser (Central States)
M. W. Tatlock (Ohio)
B. V. Howe (Rocky Mountain)

War Service Committee

R. E. Fuhrman, *Chairman* (Federal)
R. F. Goudy (California)
Dana Kepner (Rocky Mountain)
L. S. Kraus (Central States)
W. B. Redfern (Canada)
W. F. Welsch (New York)
T. T. Quigley (New York)

Finance Advisory Committee

W. J. Orchard, *Chairman*
G. J. Schroepfer, *Past President*
A. M. Rawn, *President*

The recommendation of the 1943 Standard Methods for the Examination of Sewage Committee, referred to this Board for action, that this Committee be made a permanent, constitutional Committee, was declared open for discussion. Consensus of opinion was that year-to-year continuity of the Committee was desirable but that amendment of the By-laws to include it among the constitutional committees was not necessary. It was moved, seconded and carried that this Board recommend to future Boards of Control that the Standard Methods Committee be continued from year to year as a non-constitutional, special committee.

Mr. Schroepfer introduced and Dr. Mohlman supported a recommendation that a new Industrial Wastes Committee be included among the list of special Federation committees. The need for expanded functions in this important field was stressed. Creation of a special Committee on Industrial Wastes was approved by motion, regularly seconded and carried and President Rawn stated that he would confer the chairmanship in the near future.

The Secretary suggested consideration of the continuation of the Honorary Membership Committee, such as functioned in 1942–43. It was moved, seconded and carried that all Past Presidents serve under the chairmanship of the President as the Honorary Membership Committee.

Mr. H. E. Moses (Pennsylvania) bespoke his gratification at having been elected to the grade of Honorary Member by the 1943 Board of Control and stated that he

would cherish the honor. He expressed his sincere thanks to the Board of Control and to the Pennsylvania Sewage Works Association.

A motion was made, seconded and carried that the existing fidelity bonds in the amount of $5,000 each in coverage of the offices of Treasurer and Secretary be continued. The Secretary was instructed to file the bonds with the papers of the Federation in a safety deposit box to be held in the name of the Federation.

The following banks were approved as depositories for Federation funds, upon recommendation of the Secretary, by motion, regularly seconded and carried:

Continental Illinois National Bank & Trust Company of Chicago.
Busey's State Bank of Urbana, Illinois.
First National Bank of Champaign, Illinois.

It was directed that the Series G, U. S. Government Bonds held by the Federation in the amount of $7,000 be placed in the Federation's safety deposit box.

The recommendation of the 1943 Board of Control that the 1944 Convention of the Federation be held at Pittsburgh, Pennsylvania, subject to the arrangement of satisfactory hotel accommodations, was approved by motion, seconded and carried. It was further moved, seconded and carried that, in the event that satisfactory hotel arrangements cannot be arranged at Pittsburgh, the question of 1944 meeting place selection shall be referred back to the Executive Committee.

The Secretary was instructed to direct letters of appreciation, in behalf of the Board, to all members of the Local Arrangements Committee which functioned in connection with the 1943 Annual Meeting.

It was the sense of the meeting that the Hotel Arrangements Committee and the Convention Management Committee to function in 1944 be comprised insofar as possible of members of this Board. It was recommended that the Hotel Arrangements Committee consist of one representative of the Manufacturers Association and two Federation representatives to be appointed by the President, and that the Convention Management Committee comprise two representatives of the Manufacturers Association and three Federation representatives to be appointed by the President. President Rawn acknowledged the recommendations and stated that they would receive his consideration.

Mr. Emerson, Chairman of the 1943 Committee on Honorary Members presented the rules governing the procedure of that Committee, as approved by the Executive Committee in 1943, for confirmation by this Board as a directive to future committees. The procedure employed in the past year follows herewith:

1. "Nominations to Honorary Membership must reach the Committee on Honorary Members not less than 60 days prior to the annual meeting of the Board of Control. Election of Honorary Members shall be by ballot at a regular meeting of the Board preceding the annual meeting or by letter ballot canvass not less than 30 days prior to the annual meeting of the Board. Ballots shall be secret.
2. "The Committee on Honorary Members shall advise the Board with respect to candidates for Honorary Membership.
3. "Not more than two Honorary Members shall be elected in any one year.
4. "Announcement of election to Honorary Membership shall be made at the annual meeting of the Federation."

By motion, seconded and carried, the above procedure for the Honorary Membership Committee was approved. Discussion on this motion brought out considerable sentiment in favor of election of Honorary Members in advance of the annual meeting of the Board in order that recipients of this recognition might arrange to be present at the Convention session during which awards and honors are presented.

It was the sense of the meeting that arrangements be made during the 1944 Convention for formal introduction of the President-elect and presentation of the various awards.

Mr. Schroepfer offered the recommendation that an effort be made to arrange for reprinting of selected abstracts as distributed by the U.S.P.H.S. in *Public Health*

Engineering Abstracts, in SEWAGE WORKS JOURNAL. The Board left this matter to be disposed of at the discretion of the Editor and Advisory Editor.

Chairman Cohn of the Sewage Works Practice Committee requested guidance from the Board in regard to the procedure to be followed in the publication and distribution of the Manuals of Sewage Works Practice, the first of which is expected to be ready for publication in about 60 days. It was moved, seconded and carried that the President direct the General Policy Committee to study and outline procedures for distributing all publications of the Federation other than the JOURNAL, and to report to the Executive Committee.

It was further moved, seconded and carried that as the Manuals of Sewage Works Practice are released by the Sewage Works Practice Committee, they be submitted to the Publications Committee and thence to the Executive Committee with power to act in accordance with the distribution procedure to be outlined by the General Policy Committee.

By motion, seconded and carried, the Board approved the recommendation of the 1943 Board that the next annual meeting of the Board of Control shall be held as a luncheon meeting on the day preceding the next Annual Convention of the Federation, and retained in session until all business is concluded.

Adjournment to the next annual meeting or upon call of the President was moved, seconded and carried at 3:55 p.m.

Approved:

A. M. RAWN, *President* W. H. WISELY, *Secretary*

REPORT OF SECRETARY

For Period of

OCTOBER 1, 1942 TO SEPTEMBER 30, 1943

Increased services to members, active representation of the field in matters of national significance, gains in membership and financial position, all mark the past year as probably the most productive in the history of the Federation. The broadened realm of activity held forth as one of the aims of the 1941 reorganization is now being realized, yet present accomplishments are but a good beginning and offer only a prophecy of future contributions. Amid the difficulties of the times, the demand for the types of service made possible by the Federation is greater than ever before and existing limited facilities have been extended to the utmost.

ACTIVITIES OF SECRETARY'S OFFICE

The Secretary has continued to serve on the part-time arrangement originated in January, 1941, with only one full-time assistant, in the rent-free office accommodations offered by the Urbana-Champaign Sanitary District. With the exception of the editorial functions performed by Dr. Mohlman and mechanical production of JOURNAL advertising, afforded under agreement with Chemical Foundation of New York City, all details of business management and operation have been carried out from the Urbana office. These duties include the routine services of maintenance of membership records and mailing lists, sale of publications, collection of all revenue (including advertising) and keeping of financial accounts, as well as the additional functions described herewith.

Sewage Works Journal.—Every effort has been made to assist Editor Mohlman in securing material presented at Member Association meetings for publication in the JOURNAL. The Secretary has also been responsible for production of the plant operation section designated as "The Operator's Corner" and provided a total of 255 pages of this text to the past six issues of the JOURNAL.

Considerable effort was devoted to the sale of advertising space by correspondence and by personal contact. Promotional literature was prepared and distributed. This co-operation with the Advertising Manager has resulted in production of almost 200 pages of paid advertising in the past year—the highest in the history of the JOURNAL.

From the standpoint of the Federation's contribution to the war effort, it may be of interest that non-member subscriptions to the JOURNAL have been ordered by about 150 military posts. Paid circulation of the JOURNAL as of September 30 was 3,080, including 2,609 members and 471 non-members.

Production of the JOURNAL has become complicated by the shortage of paper and of manpower in the publisher's organization. It has been impossible to adhere completely to the publication schedule.

Co-operation with Member Associations.—Under the circumstances of his dual employment, it has been exceedingly difficult for the Secretary to advance the interests of the Federation by attendance at Member Association meetings. In consequence, only three such meetings were attended by the Secretary this year; the New York State Association at New York City in January, the Maryland-Delaware Association at Baltimore in May and the Ohio Conference at Mansfield in June. The Federation was represented, however, at three meetings (North Dakota, South Dakota and Pacific Northwest) by President Schroepfer; at two meetings (Canadian Institute and Pennsylvania) by Past President Bedell and at the New England Association meeting in May by Past President Emerson.

To assist in the development of Member Association membership, the Secretary prepared and had printed a promotional pamphlet setting forth the advantages of membership. Supplies of the pamphlet were distributed to all Member Association headquarters for use at local meetings and in membership campaigns. About fifty membership inquiries were referred to Member Association secretaries during the year.

Co-operation with War Agencies.—The Secretary's office was privileged to render assistance to the War Manpower Commission, War Production Board and Office of Civilian Defense during the year. In September, a mutual service to WPB and Federation membership was rendered in the distribution of new, authoritative priorities literature to the domestic and Canadian mailing lists.

Recognition of the Federation by the above agencies as the organized representative of the sewage works field has been gratifying and has been particularly justified by the services of Vice-President Rawn with WPB and War Services Committee Chairman Fuhrman in his contact with OCD.

The year also brought about organization of the Committee on Water and Sewage Works Development of which the Federation is a co-sponsor with the Water and Sewage Works Manufacturers Association, A.W.W.A. and the N.E.W.W.A. This Committee has arranged a comprehensive and practical postwar planning program designed to fulfill the construction needs of the field at the termination of the war.

Arrangements for Fourth Annual Meeting.—The Secretary, in ex-officio capacity as a member of the Convention Management Committee, collaborated to the fullest extent in the preparations for the Second Wartime Conference in Chicago. Included in these duties were: reproduction and distribution of publicity; supervision of printing and distribution of the official notice, badges and program; reproduction and distribution of committee reports to Board of Control members; and preparation of business requiring consideration by the Board of Control.

MEMBERSHIP

The New Jersey Sewerage Conference, now represented in the Federation by the New Jersey Sewage Works Association, withdrew voluntarily as a Member Association as of January 1, 1942. The Federation now comprises 26 Member Associations.

The total Federation membership in these sectional groups is 2,544 as of September 30, a gain of 153 or 6.4 per cent over the membership of 2,391 reported on September 30, 1942. The detailed tabulation of individual memberships, attached herewith, reveals that 19 of the 26 Member Associations equalled or exceeded 1942 membership levels.

Another gratifying gain occurred in the Associate Member class, in which an increase of 7 to a total of 65 was recorded for the year.

FINANCIAL

In accordance with Section 5, Article IV of the By-Laws, each Director on the Board of Control was furnished with summaries of receipts and disbursements dated

December 31, 1942, March 31, 1943 and June 30, 1943. Copies of the auditor's balance sheet dated December 31, 1942 were also furnished each Director. Similar reports were provided to members of the Financial Advisory Committee.

Financial progress of the Federation in recent years is shown by the following comparison of net worth values:

Date	Net Worth
September 30, 1941	$10,530.21
September 30, 1942	16,034.52
September 30, 1943	23,076.26

ACKNOWLEDGMENTS

The co-operation and assistance accorded the Secretary by Officers, Directors, Committees, Member Association Officials and many individuals during the year, is gratefully acknowledged.

Respectfully submitted

W. H. WISELY, *Secretary*

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

NET MEMBERSHIP OF MEMBER ASSOCIATIONS *

SEPTEMBER 30, 1943

Member Association	Membership—September 30, 1943				Total Members Sept. 30, 1942	Net Increase
	Active		Corp.	Total Sept. 30, 1943		
	Regular	Alternate				
Arizona	15	—	—	15	20	−5
California	251	20	—	271	243	28
Central States	449	—	11	460	411	49
Dakota—North	11	—	—	11	11	
South	21	—	—	21	18	3
Federal	85	—	—	85	48	37
Florida	48	—	—	48	36	12
Georgia	24	—	—	24	28	−4
Iowa	43	—	—	43	45	−2
Kansas	19	—	—	19	18	1
Maryland-Delaware	22	—	—	22	22	
Michigan	99	12	—	111	112	−1
Missouri	13	—	—	13	9	4
New England	149	2	—	151	158	−7
New Jersey	66	—	—	66	60	6
New York	469	4	—	473	512	−39
North Carolina	55	—	—	55	38	17
Ohio	90	—	—	90	108	−18
Oklahoma	7	—	—	7	5	2
Pacific Northwest	84	—	—	84	77	7
Pennsylvania	170	—	1	171	163	8
Rocky Mountain	33	—	—	33	28	5
Texas	36	—	—	36	20	16
Argentina Soc. Engrs.	—	—	—	—	—	
Canadian Inst.	117	—	—	117	88	29
I.S.E. (England)	33	—	—	33	31	2
I.S.P. (England)	85	—	—	85	82	3
Totals	2,494	38	12	2,544	2,391	153

* Does not include dual members.

TWO NEW HONORARY MEMBERS

At the October meeting of the Board of Control in Chicago, Charles Gilman Hyde and Howard Eugene Moses were elected to Honorary Membership in the Federation. The list of Honorary Members now totals six.

The following is extracted from the letter of nomination of Prof. Hyde as submitted by the California Sewage Works Association:

"Charles Gilman Hyde was born in Norwich, Connecticut, May 7, 1874. He was graduated as a sanitary engineer from the Massachusetts Institute of Technology in 1896. He was a student under the great William T. Sedgwick, and he brought into the teaching of sanitary engineering on the Pacific Coast Sedgwick's biological viewpoint on, and approach to, the problems of sanitation. This teaching he has impressed strongly upon the many students he has had at the University of California since 1905, and his students are his greatest admirers and devoted friends. During World War I he was a Major in the Sanitary Corps, Medical Department, United States Army, performing valuable service with distinction.

"He has been consulting engineer on many problems of water supply and sanitation of considerable magnitude, of which only a few in the field of sanitation may be listed here. He was consulting engineer to the State of Nevada on pollution of the Truckee River (1918–1929); he has been consulting engineer to the San Francisco Health Department from 1932 to date; he was a member of the Board of Consulting Engineers on disposal of sewage for San Francisco, 1934–1939; he has been consulting engineer on sewage disposal for the City of Sacramento from 1938 to date; he was a member of the Board of Consulting Engineers on the disposal of sewage for Los Angeles in 1939; he was Chairman of the Board of Consulting Engineers on the disposal of sewage for seven East Bay cities in Alameda and Contra Costa Counties in 1940–41.

"He is a Life Member of the American Society of Civil Engineers, was Chairman of the Sanitary Engineering Division in 1934–1935, and a Director during 1940–1943. He is a Life and Honorary Member of the American Water Works Association.

"He was a Charter Member of the California Sewage Works Association, which he has served well on many committees. By his wise counsel he did much to make this Association a success. He was a member of the Board of Control of the Federation of Sewage Works Associations during 1931–1941, and had done valuable service on many committees of the Federation.

"Charles Gilman Hyde is a great engineer, a great teacher, and a most admirable person. His untiring efforts in the field of sanitation and his professional accomplishments mark him as one most worthy of Honorary Membership in the Federation."

Mr. Moses was nominated by the Executive Committee of the Pennsylvania Sewage Works Association, which resolution is presented herewith:

"WHEREAS, Howard Eugene Moses, Chief Engineer of the Pennsylvania Department of Health, has served this great public health agency for over thirty-five years, and has risen through all the grades in its Bureau of Engineering to become Chief by virtue of his ability and his devotion to duty and

"WHEREAS, through his technical and administrative ability, personal interest, untiring efforts and official capacity he has contributed much practical knowledge and scientific information to the field of sewerage, waterworks and public health in general; and,

"WHEREAS, he was one of the founders of the Pennsylvania Sewage Works Association in 1926; served as the original first Vice-President upon adoption of its Constitution in 1927; as President in 1928; as Member of the Program Committee for fifteen Annual Conferences; as Master of Ceremonies at every annual banquet; and as Representative of the Pennsylvania Sewage Works Association

on the Board of Control of the Federation of Sewage Works Associations since the Federation was organized and as a Director of the Federation from October, 1940 to June 30, 1943.

"WHEREAS, he rendered continuously most faithful and meritorious service as the Secretary of the Federation of Sewage Works Associations from its inception in 1928 until the establishment of the Central Executive Office in 1941; and,

"WHEREAS, with other officers, he labored diligently to perfect the successful reorganization of the Federation into its present form and has served on two of its important constitutional committees; and,

"WHEREAS, his term as Director representing the Pennsylvania Sewage Works Association terminated June 30, 1943, and he has been elected an Honorary Member of the Pennsylvania Association; now

"THEREFORE BE IT RESOLVED, That the Executive Committee of the Pennsylvania Sewage Works Association hereby nominates Howard Eugene Moses for Honorary Membership in the Federation of Sewage Works Associations and hereby presents this nomination for consideration by the Board of Direction of the Federation at its scheduled Annual Meeting in October, 1943."

FIRST FEDERATION AWARDS PRESENTED

Inception of another new activity of the Federation, that of recognizing outstanding service by the presentation of awards, was an important feature of the Fourth Annual Meeting in Chicago. Recipients of the various awards were as follows:

Harrison Prescott Eddy Award (For Research) to Harry Willard Gehm for his paper "The Separation of Grease from Sewage by Mechanical and Chemical Methods," published in *This Journal*, XIV, 4, 799–810, July, 1942.

George Bradley Gascoigne Award (For Operation) to Kerwin L. Mick for his paper "Applications of Laboratory Data in Plant Control at the Minneapolis-St. Paul Sewage Treatment Works," published in *This Journal*, XIV, 5, 937–952, September, 1942.

Charles Alvin Emerson Award (For Service to the Federation) to Floyd William Mohlman in tribute to his fifteen years of service as Editor of the JOURNAL.

Kenneth Allen Awards (For Service to Member Associations) to John Kurtz Hoskins of the Federal Sewage Research Association, Alfred Henry Wieters of the Iowa Waste Disposal Association, Edward F. Eldridge of the Michigan Sewage Works Association, Robert S. Phillips of the North Carolina Sewage Works Association and William H. Wisely of the Central States Sewage Works Association. Additional time to nominate 1943 recipients of this award has been granted by the Board of Control to the New Jersey Sewage Works Association, Pacific Northwest Sewage Works Association, Texas Water and Sewage Conference and the Institute of Sewage Purification (England).

Reviews and Abstracts

SOME COMMENTS ON SEWAGE WORKS RECORDS

By D. H. A. Price

The Surveyor, **102**, 423–428 (Oct. 15, 1943)

The purpose of operating records is

(*a*) to give proper unit control for the maintenance and improvement of efficiencies,
(*b*) to give warning of impending trouble,
(*c*) to provide evidence of needed maintenance or extension,
(*d*) to assist in determining future requirements and,
(*e*) to furnish legal evidence.

The author stresses the vital importance of correct sampling procedures. The plant structural layout and design should provide suitable points for the collection of representative samples.

Two examples are cited in the paper to indicate discrepancies in results between samples of two sewages composited from equal amounts of sample collected every 24 hours and samples collected in proportion to hourly sewage flows. Variations range from 2½ to 14½ per cent in the analytical results of the two sets of samples.

Where personnel and laboratory facilities are limited, intensive short period studies furnish a good picture to be used with occasional checks to determine what is going on and will likely happen. A few thorough analyses of sludge gas at long intervals with relatively frequent checks of carbon dioxide content will furnish sufficient data on the nature of the gas.

Dry-weather flow is an abnormal condition at many plants although it is the quantity to which the basis of design is related. At Roch Mills the dry-weather flow is 3,200,000 gallons; average daily flows during eight years averaged 136 per cent of this amount.

Caution is given regarding the spurious impression to be given by the use of too many significant figures in reporting results. Percentage purification should be expressed in stages rather than overall. It is easier to reduce a crude sewage from an oxygen absorption of 10 to 9.5 than an effluent from 1.0 to 0.5.

The use of "moving averages" in plotting curves of flows and strengths instead of plotting flows and strengths against time affords a good means of bringing out abnormalities. Averages over successive periods are taken, for example; January, 1941, to December, 1941, inclusive; February, 1941, to January, 1942; March, 1941, to February, 1942, and so on. One month is added to the total, one month is subtracted and the new total divided by 12. The curve of the resultant figures has had eliminated the normal seasonal variations, is much flatter and shows more clearly upward and downward tendencies. An example is cited of the use of this method of plotting to detect a bad leak from an underground sludge gas line. Daily plottings of gas production did not indicate the condition. A plotting of moving annual monthly averages indicated the abnormality and when the leak first occurred.

A plea is made for the use of more statistical methods in keeping and analyzing sewage records.

K. V. Hill

HIGH DAILY RATE TRICKLING FILTER PERFORMANCE

By G. Walton, L. F. Warrick, and J. Wilson

136 pp. 1943

This report was prepared under the direction of the Board of State Health Commissioners of the Upper Mississippi River Basin Sanitation Agreement. It covers an investigation of nine different plants in Iowa, Illinois, Minnesota, and Wisconsin receiving domestic sewage from populations ranging from 1,000 to 20,000. Careful records are presented. The data were collected over 12 months, comprising fifty-seven 24-hour runs, with certain simultaneous 4-hour tests and several special investigations. The primary factors affecting 5-day B.O.D. reduction of sewage and clarifier are: degree of primary treatment, biological condition of filter, filter loading, and recirculation. Within reasonable limits variables such as temperature, dosing rate and forced or natural ventilation do not, under normal circumstances, appear to have much effect. Filter loading is expressed in terms of pounds of B.O.D. per square foot of filter surface per day. The relation between filter loading and B.O.D. reduction by filter and clarifier is established. Within the limits of test data (recirculation ratios not exceeding 3) inclusion of recirculation with filter influent does not appreciably affect such relationship.

Single-stage plants may reduce the B.O.D. between 75 and 85 per cent. Recirculation increases the degree of treatment, principally as a multiple-stage filtration. The average for plants tested was slightly under 80 per cent.

Two-stage plants may reduce the B.O.D. between 84 to 95 per cent. The average for plants tested was 90.2 per cent. However, the B.O.D. of the final effluents from high-rate filter plants is rarely below 25 or 30 p.p.m.

Settled effluents contain little, if any, nitrite and nitrate nitrogen. If a well nitrified effluent is required, the settled filter effluent may be given additional treatment by sand filtration.

The effectiveness of the high-rate filter is due both to oxidation and biological flocculation. It is logical to consider the filter and clarifier as a single combined unit.

The factors of primary importance for their effect on the B.O.D. reduction of sewage by the high-rate filter and clarifier are:

(1) Preliminary treatment of sewage;
(2) Biological condition of filter;
(3) Filter loading expressed in pounds of B.O.D. per unit of filter surface per day;
(4) Recirculation.

Other variables, such as temperature of filter influent, forced or natural draft circulation of air, and dosing rate are relatively unimportant within the ranges encountered during the tests.

For normal sewage the degree of B.O.D. removed by filter and clarifier varies approximately inversely with that resulting from preliminary treatment.

The biological condition depends on the type, population density and activity of bacteria and other life dominant on the filter media. The conditions affecting environment for 2 to 4 weeks prior to the tests are important. Large fluctuations in daily loading are detrimental.

Filters should be designed on the basis of actual load applied. When recirculation is employed the total flow and its strength should be used for computation. With 5-day B.O.D. loadings from 0.2 to 1.0 lb. per sq. ft. of filter surface per day, approximately 63 per cent reduction can be obtained by filtration and clarification with filters 6 to 8 ft. deep. A maximum removal of 0.7 lb. per sq. ft. per day is indicated for all loading in excess of 1.2 lb. per sq. ft. per day.

Recirculation is essentially multi-stage filtration. However, the total applied B.O.D. load is increased thereby. Recirculation is effective in increasing B.O.D. reduction by filter and clarifier as long as the filter loading does not exceed 1.2 lb. per sq. ft. per day.

The reduction of suspended solids is about the same as for B.O.D.; 80 per cent for single-stage and 90 per cent for two-stage filtration.

High-rate filtration results in reduction of organic nitrogen compounds but in little oxidation of the ammonia.

There is no reason to believe that lack of available phosphorus limited B.O.D. reduction during the tests.

Uniform instantaneous dosage is desirable. However, no correlation was found between distribution of sewage over the filter surface and efficiency of treatment.

The use of sodium nitrate on high-rate filters may be helpful for pH control, supplying oxygen and as a source of nitrogen for biological growth.

Although quite variable, examination of the B.O.D. determinations on filtered effluent and settled filter effluent indicates that approximately 70 per cent of the effectiveness of high-rate filtration is normally due to oxidation within the filter and the remaining 30 per cent to biological flocculation and sedimentation.

The report covers various topics, viz.:

History of High Daily Rate Filters (3 pp.)
Theory of Trickling Filters (5 pp.)
Extent of Tests (8 pp.)
Test Procedure (5 pp.)
Analytical Determinations (5 pp.)
Plant Efficiency in B.O.D. Reduction (12 pp.)
Plant Efficiency in Total Suspended Solids Reduction (5 pp.)
Nitrification (6 pp.)
Utilization of Sodium Nitrate (1 pp.)
Soluble Phosphates (4 pp.)
Reduction in B.O.D. through Filter and Clarifier (15 pp.)
Variability in Strength of Sewage and its Effect on Treatment and Test Plants (15 pp.)
Distribution of Flow on Filters (9 pp.)
Factors Affecting Treatment Process (4 pp.)
Sand Filters for Final Treatment (1 pp.)
Computations for Design (7 pp.)
Summary and Conclusions (2 pp.)
Bibliography (1 pp.)
Biological Investigations (22 pp.)

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NOTE: This report is excellently presented and well worth reading, even though the data analyzed are largely from 24 hour runs. The volume of the work required doubtless precluded obtaining composite samples over longer continuous periods such as one or two weeks.

L. P.

OPERATION OF THE WARDS ISLAND SEWAGE TREATMENT PLANT

BY G. P. EDWARDS

J. Boston Society Civil Engineers, 29, 229–239 (1942)

The Wards Island activated sludge plant (New York City) went into operation in October, 1937. The plant is designed for a sewage flow of 180 m.g.d., serving 1,300,000 living on about 10,600 acres. Two grit chambers are located on the mainland. The sewage is pumped into eight cross-flow primary settling tanks, each 100 ft. square with an effective depth of 15 ft. (providing about 1 hr. detention at 180 m.g.d.). Sixteen aeration tanks are arranged in four batteries of four tanks. Each tank has four passes, each about 345 ft. long, 22 ft. wide and 15 ft. deep. Air is added through two rows of diffuser plates placed at one side of each pass. At 180 m.g.d., with 25 per cent return sludge, the detention period is 5.25 hours.

The mixed liquor flows to 32 rectangular, straight line type, final settling tanks, 12 ft. deep with an area of 7,500 sq. ft. The detention period is about 3 hours. The sewage enters at the center and flows to weirs about 10 ft. from the end wall. Four of the final settling tanks (one in each battery) are used for concentrating excess activated sludge. These tanks have a detention period of about 9 hours. The effluent passes to the East River.

Storage tanks feed the excess sludge to sludge vessels (Diesel driven; capacity each 55,000 cu. ft.), which transport the sludge to a dumping ground about 34 miles distant. Two vessels each make three trips a day. A third ship is out of service for repairs.

In 1940, the annual averages were:

Suspended Matter in Parts per Million

	Average	Maximum	Minimum
Raw Sewage	220	260	175
Primary Effluent	161	239	116
Final Effluent	16	24	11

5-Day B.O.D. in Parts per Million

	Average	Maximum	Minimum
Raw Sewage	207	251	160
Primary Effluent	168	194	139
Final Effluent	14	23	9

Practically all the sewage received both preliminary and activated sludge treatment. The per cent of return sludge averaged 44 per cent, varying from 38 to 50 per cent on monthly averages. The air used averaged 0.65 cu. ft. per gal., varying from 0.58 to 0.77 cu. ft. per gal. on monthly averages. To remove one pound of B.O.D. required 511 cu. ft. of air.

The solids in the aeration tanks averaged 1,990 p.p.m., varying from 1,525 to 2,525 p.p.m. The aeration period averaged 4.6 hours, varying from 4.1 to 5.3 hours. The sludge index (Donaldson) averaged 0.78, varying from 0.55 to 1.13. The final tanks operated at an average rate of 803 gal. per sq. ft. per day, varying from 710 to 899 gal. per sq. ft. per day.

An average of 4.1 p.p.m. of dissolved oxygen was maintained in the effluent of the aeration tanks; 3.5 p.p.m. in the effluent of the final tanks, and 6.5 p.p.m. in the discharge to the river. The pH of the raw sewage averages between 6.8 and 7.2, varying from 4.8 to 8.5 on occasion.

Some diffuser plate clogging occurred in the first 4.25 years. Plates in 8 tanks were cleaned in 1939, in 14 in 1940 and in all 16 in 1941. A solution of 25 per cent caustic is used. The tanks are drained, the plates are flushed with a hose, scrubbed with deck brushes, and dried. Caustic solution is applied and allowed to stand for 24 hours. The first pass receives two applications of caustic. With clean plates the air pressure is about 7 lb. 6 oz. per sq. inch. This builds up to 8 lb. 9 oz.

Chlorine was added to the return sludge periodically. Care is taken to avoid odors. Air drawn from the sludge storage building passes through canisters of activated carbon and is then ozonized. The odors arising during loading of the sludge vessels are similarly treated.

The effect of the plant on the Harlem River is pronounced.

The cost of maintenance and operation has trended downward:

Year	Cost per Million Gallons *Total Treatment	Sludge Disposal
1938	$11.86	$2.14
1939	11.34	2.07
1940	11.29	1.88

* Including sludge disposal.

LANGDON PEARSE

MINIMUM VELOCITIES FOR SEWERS

Final Report of Committee, Boston Society of Civil Engineers

J. Boston Society Civil Engineers, 29, 286–363 (1942)

This is the final report of a Committee to Study Limiting Velocities in Sewers. It is mostly confined to limiting minimum velocities of flow in separate sewers providing for the discharge of normal sewage. The report discusses the regulation of State Health Departments, the basis of design used by engineers and the experience with flat sewer grades and theoretical considerations. The appendices and references occupy 64 pages. As a rule state health departments require a minimum velocity of 2 ft. per sec. with the sewer flowing full or half full. In the Kutter formula $n = 0.013$ is commonly used, with a slope in the sewer to provide a minimum full velocity of 2 ft. per sec. This basis of design gives the following minimum slopes:

Size of Pipe, inches	6	8	10	12	15	18	21	24
Slope, ft. per 1,000 ft.	6.3	4	2.9	2.2	1.55	1.2	0.95	0.8

For adequate cleansing, sewers should be designed with slope adequate to develop a cleansing velocity at the minimum 24-hour average flow. In general the minimum cleansing velocity (flowing part full) is set at 1.28 f.p.s.

LANGDON PEARSE

THE CYCLO-NITRIFYING FILTER

BY J. H. EDMONDSON AND S. R. GOODRICH

Institute of Sewage Purification, Annual General Meeting at Leeds, November, 1943

The Coisley Hill works of the Sheffield Sewage Disposal Department was designed for a population of 25,000 in 1938 and in 1940 the population had increased to 27,000. The experimental work was initiated to find a temporary solution to the difficulties of operation arising from this fact. The plant consists of grit chambers, screens, primary sedimentation followed by bio-aeration (Sheffield system). The sewage is entirely domestic with a dry-weather flow of 13 gallons per capita and an average influent suspended solids of 547 p.p.m.

The activated sludge bulked very badly and none of the available remedies such as weighting with soil, etc. proved effective. The addition of iron in the form of copperas (50 p.p.m.) and lime (15 p.p.m.) to the primary sedimentation tank effluent or to return sludge was tried after washing completely the bulking sludge. This procedure proved effective during the winter and spring months but during the summer dry weather flow condition, the sludge began to bulk again. Increasing the dosage of chemicals checked the bulking but had an adverse effect on the quality of the effluent. The chemical treatment of the sewage prior to sedimentation with the purpose of reducing the strength of sewage entering the bio-aeration unit proved to be costly.

In order to increase the oxygen supply, well-nitrified effluent from a high-rate filter was added to the sewage entering the bio-aeration unit. The effluent from the bio-filtration unit was applied to a high-rate nitrifying filter and the effluent returned to the bio-aeration unit.

A laboratory filter of 3-in. diameter filled with ½-in. medium was used initially and dosed with final effluent. Application rates were increased from 200 to 800 gal. per cu. yd. per day. Twenty to thirty p.p.m. of nitrate nitrogen was found with 600–700 gal. application per cubic yard. A concrete tube filter of 3-ft. diameter, 7 ft. deep was put in operation. The medium was slag and clinker varying from 2–3 in. in the bottom to ½–¾ in. at the top of the filters. At a 1,000-gal. cu. yd. rate 24.3 p.p.m. of total oxidized nitrogen was produced and at 1,400-gal. rate 16 p.p.m. was produced but the quantity of oxidized nitrogen produced per cu. yd. was irrespective of the quantity and quality of the feed applied to the filter and averaged .24 lb. per cu. yd. per day with an oxygen equivalent of .65 lb. per cu. yd. per day. No clogging of the filters occurred when the feed to the filter contained small quantities of sludge-forming material derived from the effluent of the bio-aeration system.

Various mixtures of sedimentation-tank effluent and nitrified-filter effluent were aerated in the laboratory by surface aeration on a fill-and-draw basis with a 7-hr. aeration period each cycle. The B.O.D. of the mixture after treatment made with 1 to 1½ volume of nitrified effluent to 1 volume of tank effluent was 18 p.p.m. as compared with 57 p.p.m. of the tank effluent treated by aeration only.

Next a filter was placed in the circuit with one of the bio-aeration units. The filter was 30 ft. in diameter and 7½ ft. deep filled with graded and honey-combed clinker varying 3–6 in. at the bottom to ½ to ¾ in. at the top. Effluent from the filter flows by gravity to the aeration tank while the final effluent is pumped to the filter. It is provided with a revolving distributor with film jets. The sludge returned to each bio-aeration unit was a mixture discharged from both units. When dosed at the rate of 900 gal. per cu. yd., the filter produces 180,000 gal. of nitrified effluent which is equivalent to the dry-weather flow treated by each bio-aeration unit. The production of nitrates from the plant scale filter at the rate of 500 gal. per cu. yd. was only 11.6 p.p.m. as compared with the performance of the small-scale experimental unit which produced 24.3 p.p.m. when dosed at the rate of 1,000 gal. per cu. yd. This was attributed to the distribution which was not as uniform as that in the small-scale experiment. The distributor was then remodeled and fitted with spray jets to give a rainlike distribution. The rate of nitrate production was doubled to 20 p.p.m., which, when returned in the volumetric ratio of 1:1, contributes 70 p.p.m. of oxygen, both in the combined and free forms. The filter was clean and did not clog. There is some suspended matter discharged from the filter. Resting periods and low temperatures adversely affect the efficiency of the filter.

When the filter was matured chemical precipitation and addition of chemicals to correct bulking was stopped. The effluent from the control bio-aeration unit had a B.O.D. of 44.3 p.p.m. while the bio-aeration unit receiving nitrified filter effluent had a B.O.D. of 24.1 p.p.m., a reduction of 45.6 per cent. In a large-scale experiment lasting over a year there has not been any indication of bulking in either unit in spite of the fact that one of the units was operated as straight aeration plant and the sludges from both units were mixed.

The effect of recirculating nitrified filter effluent to trickling filter was also studied. Primary settled effluent was mixed with the nitrifying filter effluent and passed through the trickling filter. The trickling filter was 3 ft. in diameter and 7 ft. 9 in. in depth filled with honey-combed clinker varying from 3–4 in. in the bottom to 1–2 in. at the top. The total rate of application on the trickling filter varied from 1,000–1,500 gal. per cu. yd. per day. The ratio of sedimentation tank effluent to nitrified effluent varied from 1:3 to 1:1. The filter has been operated for a period of 2½ months and except for an initial period of ponding it has worked satisfactorily. The B.O.D. of the effluent from the filter through which nitrified effluent was circulated varied from 11 to 19 p.p.m. The rate of application of the settling tank effluent was 275–500 gal. per cu. yd. per day and considering both filters the effluent from the settling tank was applied from 177 to 333 gal. per cu. yd. per day. Previous experience had indicated that sewage from this source could be applied on normal trickling filters without recirculation of nitrified effluent at the rate of 50–70 gal. per cu. yd. per day.

In introducing the paper the author remarked that when equal volumes of settling tank effluent and nitrified effluent were applied to the trickling filter a gray film built up on the surface of the filter which was allowed to develop and clog the filter. When nitrified effluent alone was applied to this filter in two days the filtering material was perfectly clean. It has further been found that when nitrate has been completely reduced at $2\frac{1}{2}$-ft. level, due to application of a relatively greater volume of settled effluent to nitrified effluent, the filter begins to show signs of distress and that a reserve of nitrate throughout the filter is essential. The effluent from the bottom of the filter ($7\frac{1}{2}$-ft. level) showed little if any improvement over the $4\frac{1}{2}$-ft. level, indicating that the depth of the filter could be reduced without impairing the quality of the effluent.

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